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ABSTRACT

Presented are 26 units (each title beginning with a letter of the alphabet) intended to serve as points of departure for teachers and students who desire to increase their awareness of the marine environment. Each unit includes ideas and activities drawn from a variety of content areas so that teachers of many different subjects at the junior high and middle school levels can make use of them. The units, focusing on the Gulf of Maine, may be used in their entirety or used as idea or activity sources to infuse into the usual curriculum. General topic areas include: marine art; boats, ships, and navigation; fish and fisheries; sea mammals; sea birds; tides and current; aquaculture; recreation; marine geology; marine navigation aids; marine biology; marine plants; and marine history. Among the specific topics/activities included are: building a saltwater aquarium; boat design contest; fish aging studies; activities of the State Department of Marine Resources; beach study activities; recognizing parts and kinds of vessels; scrimshaw and weather lore experiences; steps involved in introducing marine education; Northern New England Marine Education Program; a study of sea star behavior; and glaciation. A packet of student materials is provided. (JN)

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What Are the ABC's of Marine Education?

An Introduction to Marine Education in the Gulf of Maine Region

Units Revision Team
John W. Butzow, *Project Director*
John W. Butzow, Gail Shelton, Peter Corcoran, and Charles J. Gregory, *Curriculum Writers*
Judith Cooper, *Illustration and Design*

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Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Contributors

NNEMEP Staff

Project Director: John Butzow 1975-82
Project Assistant Directors:
- Richard Schlenker 1976-77
- Less Picker 1977-78
- Harry H. Dresser 1978-79
- Peter Corcoran 1979-81

Major Contributors:
- John Butzow
- Clayton Carkin
- Peter Corcoran
- Victor DeSilvestro
- Harry Dresser
- John Eiseman
- Richard Glueck
- Charles Gregory
- Ruth Gruninger
- Richard Hansen
- Deborah Hartney
- Wesley Hedlund
- Mildred Jones
- Philip Kane
- Win Kelley
- Steven Kilfoyle
- Daniel Lancor
- Jean MacConnell
- Julia Steed Mawson
- Chris Morgner
- Less Picker
- Robert Pratt
- Richard Schroeder
- Gail Shelton
- Stephanie Stern
- Lorraine Stubbs

Staff Assistants:
- Julie Brown
- Deborah Hartney
- Michael Shirley

Developmental Art Work:
- Peter Archambault
- Lori Dombek
- Carol Nichols
- Harry Dresser
- William Hepburn

Developmental Photography:
- Less Picker
- John Butzow
- Clarence Barber

Manuscript Preparation:
- Mary Brown
- Elaine Mitchel
- Page Eastman

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Revised Marine Education Infusion Units for Middle School-Junior High School

Have You Been to the Shore Before? A Marine Education Infusion Unit on Seashore and Aquarium Life

What Adventures Can You Have in Wetlands, Lakes, Ponds, and Puddles? A Marine Education Infusion Unit on Wet Environments

What is our Maritime Heritage? A Marine Education Infusion Unit on Ships and Shipping

Is Our Food Future in the Sea? A Marine Education Infusion Unit on Aquaculture and Sea Farming

How Do People Use Lighthouses and Navigational Charts? A Marine Education Infusion Unit

Do You Know Our Marine Fish? A Marine Education Infusion Unit on Finfish of the Gulf of Maine

Do You Know Our Marine Algae? A Marine Education Infusion Unit on Algae of the Gulf Of Maine

What Are the ABC's of Marine Education? A Marine Education Primer Dealing with Many Topics

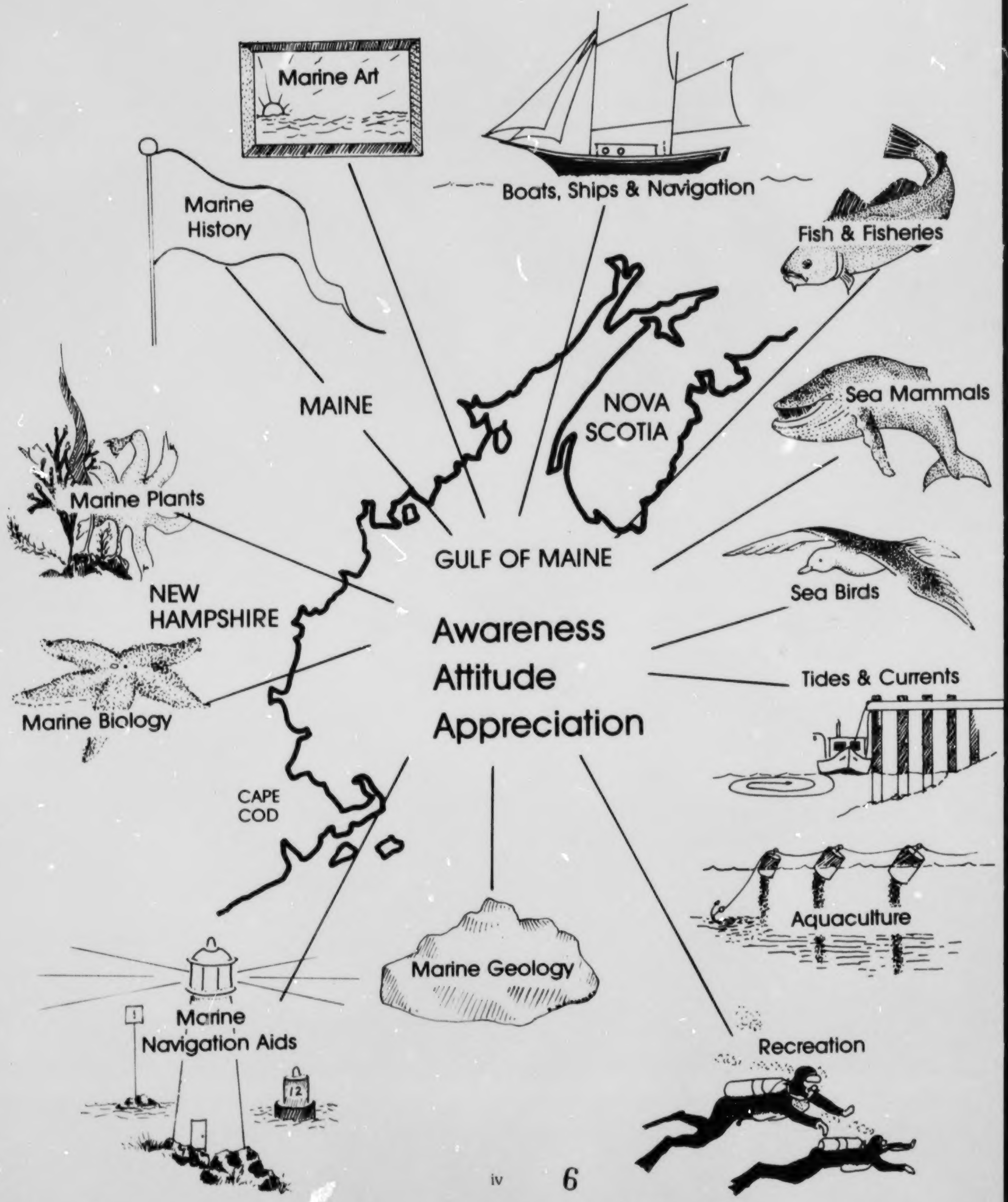
Original — Trail Editions (For Grades K-12)

Clams and Other Critters
Marine Art
The Aquarium
The Beaver
The Lobster
Whale Multi-disciplinary Studies
Our Heritage of Ships
Shipping, Ships and Waterways
The ABCs of Celebrating Year of the Coast in Your School
Have You Ever Been to the Shore Before?
Blue Mussel
Lighthouses
Wetlands
Seaweeds
Aquaculture
Navigation

More than one hundred teachers and members of past NSF sponsored summer institutes have trial tested and critiqued these units.

Marine Education

Ocean & Coast Conceptual Scheme


Marine Art
Boats, Ships & Navigation
Marine History
Fish & Fisheries
MAINE
NOVA SCOTIA
Sea Mammals
Marine Plants
GULF OF MAINE
Sea Birds
NEW HAMPSHIRE
Awareness
Attitude
Appreciation
Tides & Currents
Marine Biology
CAPE COD
Aquaculture
Marine Geology
Marine Navigation Aids
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Recreation

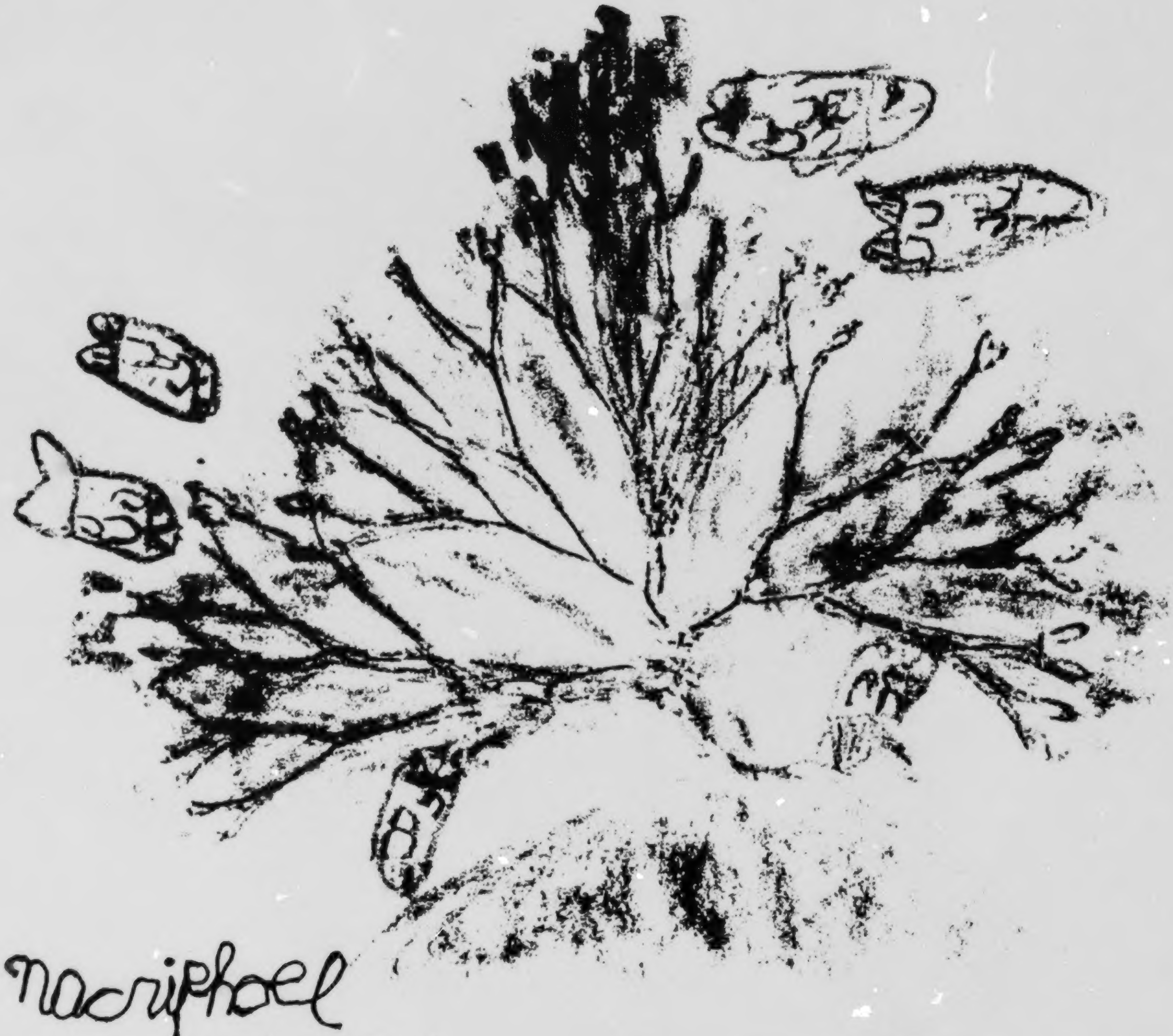
Foreword

Marine education is a relatively new term embracing a multi-disciplinary approach to learning about the marine environment: how it relates to people and how people change and relate to it. These units are intended to serve as points of departure for teachers and students who desire to increase their awareness of the watery world of this blue planet. Each unit includes ideas and activities drawn from a variety of content areas so that teachers of many different subjects at the junior high and middle school levels can make use of them. These units may be used in their entirety or used as idea or activity sources to infuse into the usual curriculum.

Our objective is to help teachers make learning more water-related. We did not plan a structural sequence of topics for grades five through nine, but rather offer these teachers guides and student pages for your consideration.

The general focus within these units is the Gulf of Maine. As the Gulf extends from Cape Cod to Nova Scotia it washes an extremely long and varied coast. We have dredged and seined themes from the activities, concerns, organisms, vessels, and the past of this vast watery region of North America. We aim to be inclusive rather than exclusive, suggestive rather than factual, and stimulating rather than expert. Our hope is that your students will become more questioning, interested, and critical of watery concerns. We hope your use of these materials will add water back into our culture.

John W. Butzow



Drawings by Nacriphoel Ruge — age 7

A Note on Measures and Genders

Wherever practical, metric measures are used in this unit. Teachers are urged to use metric measures descriptively as well as in student measurement and observational activity.

A number of occupational words have as yet no generally used non-sexist equivalent. We have therefore retained use of the terms fisherman and lobsterman for either sex.

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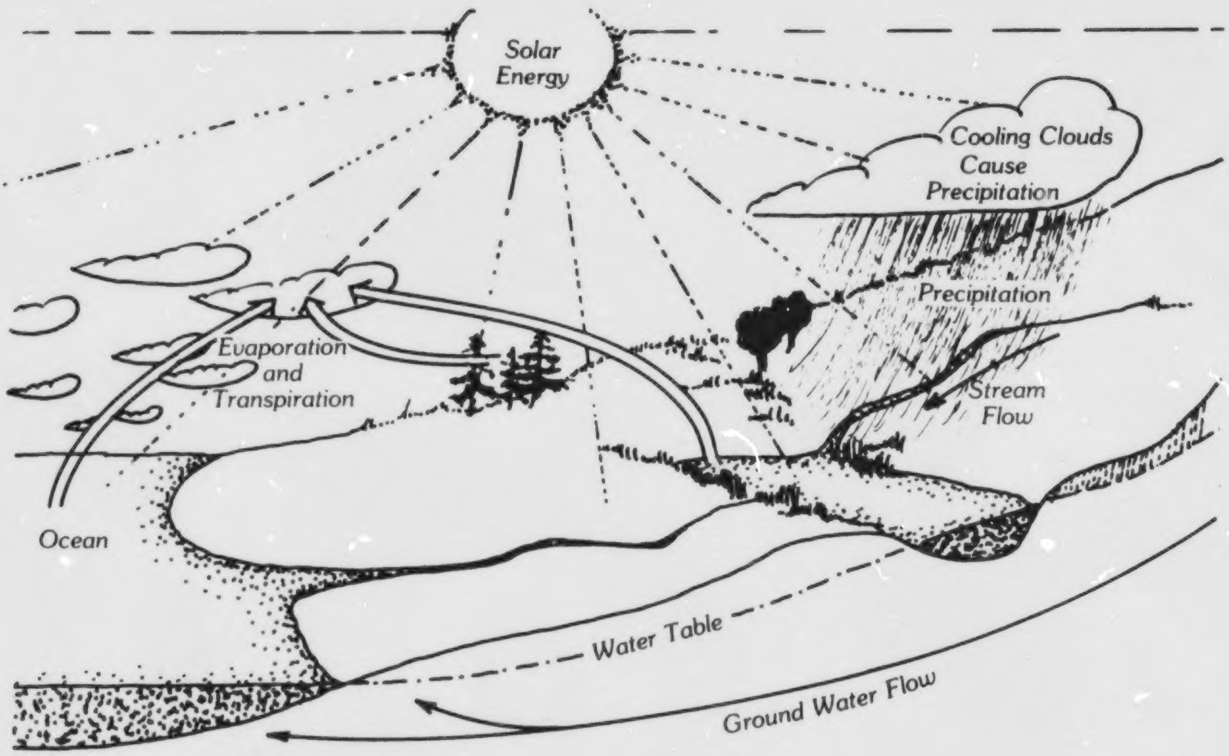
Quahog Diagrams
Sea Star Student Guide
Blank Graphs for Tidal Activities
Diagram of the State of Maine
Whale Chart and Whale Tail Cards
Yacht Race Chart

Introduction: The World of Water

HYDROLOGIC CYCLE



The idea of a "world of water" is the key concept in marine education. All the oceans, rivers, streams, ponds, lakes and ground water systems of the world are interconnected through one grand process known as the water cycle. In this cycle, water leaves the surface of the earth through evaporation, caused by heat from the sun's rays, or via transpiration from the leaves of plants. The gaseous water, called water vapor, is carried aloft by rising air currents where it is condensed into raindrops or snow which group into clouds. When the clouds become too heavy with droplets or flakes, they fall to earth, replenishing the oceans, rivers, streams, ponds, lakes and ground water. The cycle continues.

Not only are the earth's water supplies related through the water cycle, but, also, through a physical connectedness on the earth's surface: most rivers, lakes and streams eventually end up flowing into the oceans. Because of this system, the only real difference between ocean water and fresh water exists: the amount of minerals (generally called "salt") found in each. Streams, rivers and raindrops erode the rocks of the earth's surface. The minerals and rock particles that result from this erosion are carried by rivers to the seas. Thus, all of earth's waters contain some "salt"; because many rivers flow into the ocean, the ocean ends up containing more salt than any individual river.

Thus, marine education is really concerned with all of the earth's water, "fresh" and "salt" and all the physical, chemical and geological processes associated with this water world as well as all the life contained within it. But, also, and perhaps more importantly, marine education looks at an "earth of water." Photographs of our earth sent back from space revealed our planet to be truly a water planet. All the "blue" areas on the earth constitute nearly 75% of its surface; water is what makes earth unique among all the planets of the solar system, and one of the chief reasons why we have life as we know it on earth.

We see, then, the marine education focuses on many aspects of water — the interrelationships within the "water world" as well as the idea of an "earth of water." But the concept of the "world of water" extends even further to a consideration of how human beings and all our fellow land organisms are connected to this world. First, we are totally dependent upon water for survival; our bodies are composed of over 65% water; we can live for months without food, but only a few days without water. In addition, we have a rich heritage of water-related activities: the world of water has been used by humans for food, transportation, commerce, energy production, industry, minerals, oil and gas, military protection, adventure, recreation and artistic inspiration. Our connections to the world of water run deep and extend far back into the roots of our past as a species and as a civilization.

The goals and objectives of marine education, are to teach about these many aspects of the world of water. According to Harold Goodwin, a leading American marine educator, marine and aquatic education is "that part of the total educational process which enables people to develop a sensitivity to and a general understanding of the role of the seas and fresh water in human affairs and the impact of society on the marine and aquatic environments."[1] It is our purpose in creating this guide to help you, as teacher, begin to help you students to develop that sensitivity and understanding of which Goodwin speaks.

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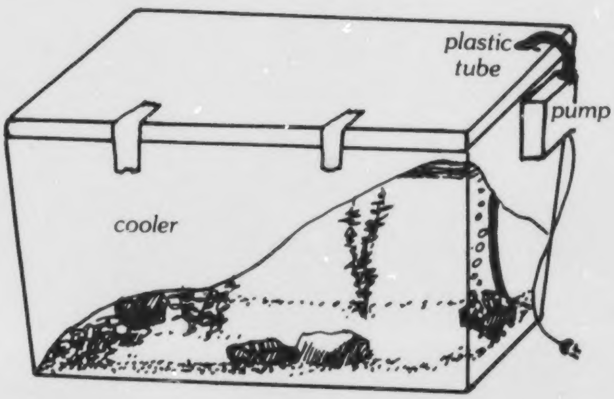
[1] **Goodwin, Harold L.** ***An Introduction to Marine Education: To Inform Americans About the World of Water*** (Draft for comment). Published by the University of Delaware Sea Grant College Program, University of Delaware, College of Marine Studies, Newark, Delaware, 19711.

A is for Aquarium

Establishing a saltwater aquarium in your classroom can be difficult and a little tricky, but it can also be very rewarding and a powerful teaching tool. The instructions which follow should answer many of your questions. The activites are from a Northern New England Marine Education unit entitled, ***Have You Been to the Shore Before?*** It contains good rocky shore background information, drawings of marine plants and animals, and extensive material on seacoast field trips including resource people and sites.



Equipment Needed:
Styrofoam cooler, aerator, pump and plastic tube, seawater, sea creatures, beach sand and rocks.

Method:
Your aquarium tank will be simply a styrofoam picnic cooler with several strips of filament tape added for hinges.

The only other modification needed is a hole which you can punch in the top of the cooler with a sharp pencil. You can prepare your aquarium at beachside as you collect your classroom creatures. First, you will need some coarse sand, enough to cover the bottom of the cooler to a depth of three or four centimeters. You should add two or three rocks about the size of your fist. Next, "fill" the cooler with sea water to a position about four centimeters below the place where top fits into the cooler. You may want to scratch a line at your fill position for future reference.

With sand and rocks in place you can begin to collect creatures. This should be done at low tide and of course in a location where you have permission to collect. Local ordinances or state regulations during a "red tide" period may prohibit taking certain species, especially clams and mussels. A good collection for a cooler aquarium might be two or three large snails or welks, a half dozen small snails or periwinkles, two or three very small green crabs, several clusters of six to ten mussels which often come attached to rocks (keep them together) and one or two of each of the other living creatures you happen to see. The rule for keeping things alive later in the classroom is by keeping a few creatures and replacing them as they die or are eaten.

A cooler aquarium as described above with naturally cold sea water will last overnight in the trunk of your car without further cooling or aerating. To be on the safe side you could add a sealed bottle containing frozen freshwater or a carefully sealed plastic bag of ice cubes as coolant. ***Never*** put freshwater ice directly into your aquarium.

Once you have arrived home, put the plastic tubing onto your aeration pump and insert the tube through the top into the water. Weigh the tube under rocks below the sand surface. Be careful, however, not to crush the end of the tube with the rocks. Each day check the temperature of water in the aquarium. It should stay between four and ten degrees celsius (40-50°F). Bagged ice or sealed bottles of frozen water will do the trick. Send the aquarium home with trained volunteer students over vacation periods for appropriate maintenance.

To maintain your aquarium, you will have to keep the salinity or salt content of the tank stable. When you first fill the aquarium, mark the water level with a scratch mark on the tank. The density of the water in the aquarium is important and can be checked with a hydrometer (available at a pet store or you can make one from the information in letter "E."). It should show a reading of 1.025 when natural seawater is filling the aquarium. As water evaporates and the salt concentration in the tank rises, pure water should be added to return the original water level mark. Any salt accumulating on the edge of the glass should be scraped off the sides and returned to the tank. Tap water should set overnight, uncovered, to removed chlorine before it is added to the tank.

The starfish and crabs can be fed with frozen clams. Turtle food and fish food may be added to the water to provide nourishment for mussels and small fish. For a while you may try an experiment of adding a few extra mussels and small fish. In this more natural situation, crabs and starfish will find their own dinners. You and your students will have the opportunity to watch crabs and starfish opening the mussels. The small fish will "clean up" after the crabs are finished.

There are a few simple steps to remember for a successful aquarium:

1. Use natural seawater and maintain a constant water level.
2. Keep the water temperature low. If you need to reduce the temperature in your tank, float ice cubes in plastic bags or containers. Never add ice cubes directly to the water. Also, avoid rapid temperature changes. The range is 4 to 10 °C.
3. Keep the water well aerated.
4. Do not overcrowd your aquarium.
5. Find out which animals are voracious predators. You may want to isolate these.
6. Feed your animals regularly and remove all uneaten food or dead animals to prevent fouling.
7. To avoid excess evaporation, keep the top on the aquarium "cooler" covered when not in classroom use.
8. Keep the aquarium out of direct sunlight.

Specimens can be obtained from science supply houses, but is often less expensive and more interesting to make your own collections. You can expect to find mollusks, crabs of various species, starfish, small marine fish, snails, barnacles, anemones and urchins, to name a few. Around a jetty or a rocky beach at low tide is the best place to look and collect. Collect various types of seaweed to enhance the attractiveness of the aquarium. You probably will not need any supplemental lighting unless you want to support several species of the green algae. The predominant red and brown seaweeds do fine with regular fluorescent or incandescent light from your ordinary lighting. If you want to work with seaweed (marine algae) extensively you should keep an aquarium just for plants. An interesting alternative is to press seaweed for an attractive display.

Science Supply Houses In Our Region
There are many fine biological materials companies. Several in our region can supply regional specimens with quick turn around time, often by telephone orders.

Berkshire Biological
240 Florence Road
P.O. Box 404
Florence, Massachusetts 01060
(413) 586-6149

Connecticut Valley Biological Supply Company
Southampton, Massachusetts 01073
(413) 527-4030 or toll free
(800) 628-7748

Science Activities to be Used with Your Saltwater Aquarium

1. What are the requirements of the plants selected? Determine predator-prey relationships of the animals selected for the aquarium. How do these organisms fit into the food web? Make a chart illustrating the role the animals and plants in your aquarium play in the food web. This serves as a good classroom bulletin board project.
2. Stop feeding the aquarium animals frozen food and stock the aquarium with a large supply of mussels. Observe results.
3. Speculate upon or do library research on the effect a variation of the salt content of the aquarium water would have on the aquarium's tenants.
4. Small clear plastic containers from the meat market (about 10 x 10 x 10 centimeters) make fine observation containers. Buddy teams of students can work with hand lenses to observe smaller parts of creatures up close. To avoid disruption of your aquarium, you may want to keep a five gallon "jerry can" of seawater in the refrigerator to fill your observation containers. Stainless steel of better plastic kitchen strainers make good catching gear. You might want to use the observation form "My Special Critter" from the pocket to help students concentrate.
5. Using liter pitchers, determine the capacity of your aquarium.

Language Activities:

Have each student keep a journal of daily observations of the plant or animal of his choice. The journal may be picture or script, depending on age level.

Math Activities:

1. Record, chart or graph the life span of the different animals in the aquarium.
2. Record, chart or graph the growth of any animals or plants which can be measured.
3. Measure the water temperature. Graph the temperatures over time.
4. Record periods of greater or lesser animal activity. Graph in relation to time of day, periods of days or months of year.

Art Activity:

Many dried sea creatures especially starfish, scallops, sea urchins and sand dollars that have interesting but flat sides can be used to print with. One method is to spread ink liberally on a board with a rubber ink roller available from craft shops. The procedure is to "ink" the dried creature and press it onto unglazed paper. For interesting and creative effects a variety of colors of ink can be used with interesting arrangements of creatures. The truly creative will also print t-shirts, cloth pendants and use proceeds to sponsor field trips. A variety of inks and paint can be used. For starters you might try Pilikan Encre DeChine 17 Black.

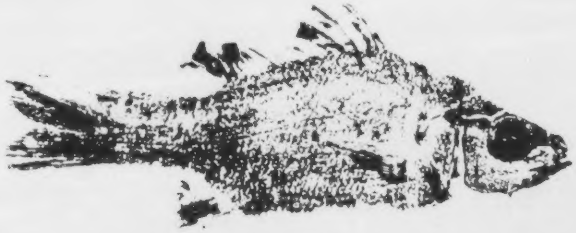
Fish can also be used to print. This process is described and illustrated in letter C as well as in the NNEMEP units called ***What Adventures Can You Have in Wetlands, Lakes, Ponds and Puddles?*** and ***Do You Know Our Marine Fish?***

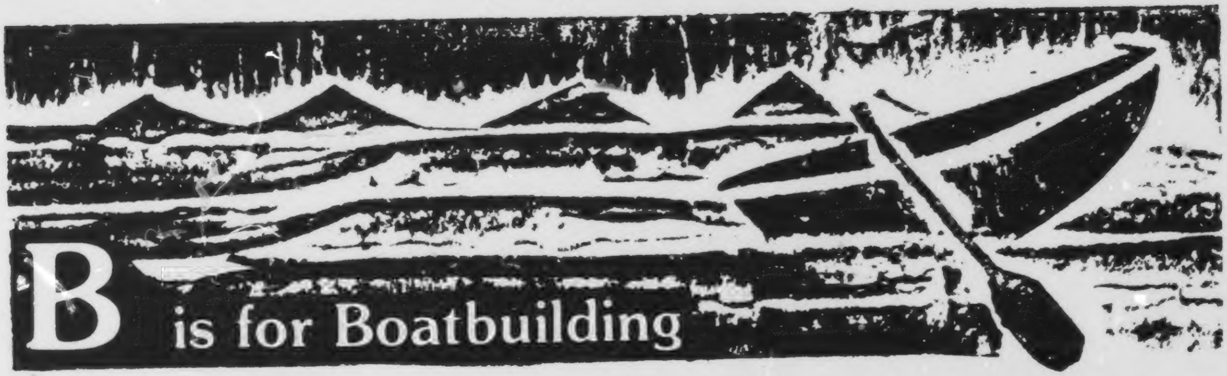
Resources:
Bower, Carol E. ***Keeping a Marine Aquarium: A Guide for Teachers.*** The Children's Museum of Hartford, Connecticut, 1975. Well-organized and well-written.

King, John M. and Kelley, William E. ***Marine Aquariums: Principles and Practices.*** Aquarium Systems, Inc., An excellent 25-page booklet — theoretical and practical.

Miget, Russel. ***How to Set Up and Maintain A Saltwater Aquarium.*** Publication No. TAMU-SG—81-504 Marine Information Service, Sea Grant College Program, Texas A & M University, College Station, Texas 77843.

The Northern New England Marine Education Project publishes a Marine Education Infusion Unit entitled ***Have You Been to the Shore Before?*** which deals in detail with seashore plants and animals. This and other products of NNEMEP are described under letter N.





B is for Boatbuilding

"Once upon a time not long ago, three generations of Maine craftsmen wrought from raw pine, oak, pitch and iron the worthiest, most appealing sailing ships the world had yet seen. With one eye to commerce and one to nature, they built vessels that deflected harsh forces to human purposes and attained a level of art in the process. Not overnight, but one keel, one mast, one good ship at a time."
— Author unknown

Boat building is an important part of our state's history and your students' heritage. Many fine resources exist for all ages of learners, and a few of finer ones are listed in this section.

One of the most pleasant and exciting ways to put your youngsters in touch with this living tradition is to visit a boat builder. We do recommend, that if you're lucky enough to afford a field trip, you enrich its values with pre- and post-trip lessons. Do be sensitive to a yard's point of view that time is money and appreciate that you may be a costly interruption.

A guide listing numerous boat yards was prepared by John F. Battick, Department of History, University of Maine at Orono. The guide is found in the NNEMEP Unit, ***What is Our Maritime Heritage?***

Sink-it, A Tragic Activity

If you can or even if you can not visit a boatyard or maritime museum you may want your class to engage in the great sink-it contest. In this contest, size number one paper clips are used as boat passengers and boats are designed and fashioned from modeling clay. To be fair, students should weigh out the same amount of clay. Twenty five grams works just fine. While the contest works well in small containers such as photograph developing trays or bread loaf pans, a child's wading pool can be used simultaneously by the whole class.

Contestants should have a few minutes to fashion their clay vessels. Each contestant should be given a handful of paperclips, and, at the signal, clips are added one by one. The number of clips to just sink each vessel should be recorded on the blackboard. Cheering for a favorite should be encouraged within reasonable limits. You may want to hold this part of the activity outdoors in good weather.

Keep the win, place and show vessels and have their designers sketch their designs on the board. Discuss possible reasons for success. Class reading on vessel design could follow. Most good encyclopedias have illustrations. After the library is picked clean for ideas, your class would benefit from running the contest again.

This idea is also used in the NNEMEP unit, ***What is Our Maritime Heritage?*** which also contains other boat design activities and bibliographies. More ideas on clay boats can be found in the ESS unit by that name (see Resources section).

Resources

The Maine Maritime Museum's Apprenticeshop at Bath has produced some elegant materials over the last few years. Under the direction of Lance Lee, three monographs produced with the support of the National Endowment for the Humanities, might serve as an inspiration for you. They are free. A pamphlet, ***Half-Modelling,*** with templates on thick stock paper is also available. For this, there is a small charge.

Your students would also enjoy:

Michael and the Mary Day by Harry W. Smith (published in Camden, by ***Downeast,*** 1979)

Any of the Elijah Kellogg's Elm Island stories, published in Boston by Lothrop, Lee, and Shepard and Company, if you can obtain them, written one hundred years ago, will appeal to many youths today:

Lion Ben of Elm Island, Volume 1, 1871.

Charlie Bell, The Waif of Elm Island, Volume 2.

The Ark of Elm Island, Volume 3, 1869.

The Boy Farmers of Elm Island, Volume 4, 1869.

The Young Shipbuilders of Elm Island, Volume 5, 1870.

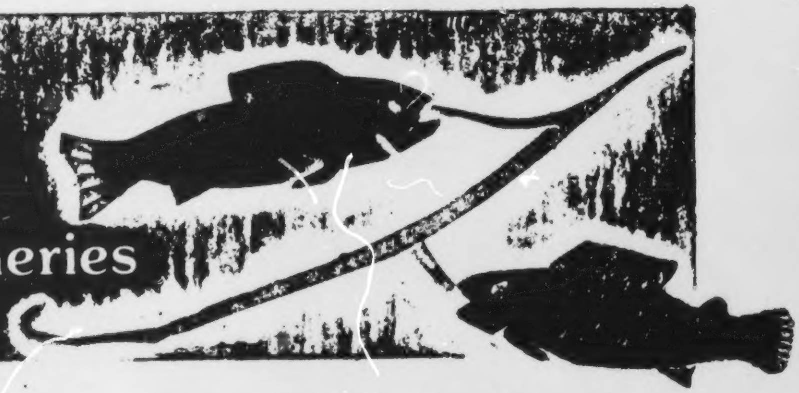
The Hard-Scrabble of Elm Island, Volume 6, 1873.

The Elementary Science Study (ESS) kit for Clay Boats is excellent as an introduction to the concept of buoyancy. It is very popular with children because of its manipulative nature — and the magic of playing with water. It is available from the Webster Division, McGraw-Hill Book Company, New York, 1969.

The State of Maine maintains its own boat-building school at Washington County Vocational Technical Institute at the Marine Vocational Center, Eastport, Maine. Write for a school catalog to:

Washington County Vocational Technical School
Calais, Maine
04619

C is for Commercial Fisheries



One fairly easily done activity related to commercial fish is using a fish scale to determine approximate age. Fish, like trees, grow faster during warmer seasons where more nutrients are available. Fish scales are easily obtained from a sports fisherman or from the fish market. Remove scales from the midsection of the fish and count lines out from the center. These lines represent colder seasons. In general, each line represents one winter and hence the total number of lines provides a rough estimate of the age of the fish. In the pocket is a sketch drawn from a scale of a six year old striped bass caught in the Penobscot River. You can make an overhead transparency of the sketch and then do the aging activity with your whole class or you can use the transparency to introduce the process and then have teams of students count lines on different scales of the same fish. Older students can make data tables and averaging to arrive at the best guess at the age of the fish.

Scales can be prepared in several ways. They can be placed between two glass microscope slides and then the ends can be taped together to prevent the scale from drying and curling up. Viewing scales can be done with a standard microscope on low power, or with a binocular or "stereo" microscope. These are easier for youngsters and usually only have low power. The scale can also be projected with a microprojector.

Teachers who mount their own 35mm photographic slides may be familiar with glass slide mounts. Scales can be mounted between glass slide mounts and then can be projected in the same way as any 35mm slide.

Good counting!

D is for DMR

The Department of Marine Resources has the ability to work with teachers and schools in planning curriculum and setting up programs. There is a speaker service with slide presentations which can be tailored to your particular needs. Publications for use by teachers, which are free of charge, are abundant in the DMR library, as are many technical research reports for further study interest of teacher background material.

Lorraine Stubbs is the Marine Science Educator who will be happy to assist you with these services. She can be contacted at the following address:

Lorraine L. Stubbs
Department of Marine Resources
State House, Station 21
Augusta, Maine 04333
(207) 289-2291

Slide Presentations, Other Media and Equipment

The Gulf of Maine

Lobster Slide Show

Herring Slide Series

Field Trip to a Rocky Shore (either secondary or elementary school)

Marine Careers

Marine Worms

Research Films

The Anadromous Fish Project

Fishing Equipment and Methods

Other: Set up visits to an aquarium, Research Lab of DMR or Bigelow Lab

The Fishes of the Rocky Shore

Ms. Stubbs personally narrates these and can adapt to any K-12 grade level. She often brings hands-on materials as part of the presentation, and answers students' questions.

Materials of Special Interest to Teachers.
The American Lobster Unit 13
The Atlantic Herring Unit 14
The Steamer Clam Unit 15

extensive teacher background material, numerous illustrative aids on description of fishery, good bibliography, upperclass grades

Information Sheets for Teachers and Students
The Estuary
The Sturgeon

Biography of Food from the Sea
nutrition information, description, illustration, preparation of species such as clams, cod, crab, haddock, pre- and post-tests, adaptable to middle & upper grades

Fisheries Information on other species of interest
habitat, life cycle, fishery research information with illustrations. Request by the species' name.

Wide variety of materials dealing with Coastal and Marine topics.

E is for Estuaries

Teacher Background

This background information is edited from the report of the Penobscot Watershed study, and is reproduced here with permission of the University of Maine at Orono Office of Water Resources.

A map of the lower Penobscot Watershed is provided in the packet.

The Penobscot estuary extends from the head of tide at Bangor, south 52 km to Searsport. The estuary from Bangor to Bucksport flows in a narrow basin with a mean (average) width of 1.9 km. The mean depth of the estuary basin is 9 m, with maximum depth of 26 m. The surface area is 96 km^2 with a volume of 849 million m^3 at mean low water. Mean high water at Bangor is 4.0 m above sea level, and mean high water at Bucksport is 3.4 m.

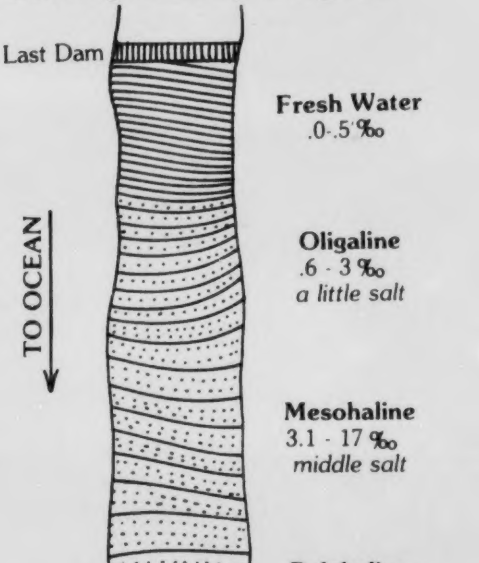
At the base of the Bangor dam is a large pool which appears relatively clean but is slightly turbid due to the violent mixing that occurs from the water spilling over the dam. The pool stays open year round and in the winter harbors several hundred waterfowl. A moderate amount of algae and submerged vegetation grow in the pool.

From the pool to the end of the area there are several coves, tidal flats and areas of extensive tidal marsh. Physically, the Penobscot estuary is partially mixed or moderately stratified or zoned by salt concentration. In this type of estuary the salinity increases both with depth and proximity to the ocean. The partial mixing has important biological implications because pollutants, in addition to the salt concentration, are unequally distributed throughout the water column.

Oceanographers report salinity in parts per thousand (‰) rather than percentage (%) or parts per hundred. Typical "salt" water in the Gulf of Maine is 34‰ or 3.4%. This is approximately equivalent to a quarter teaspoon of salt to a liter (or a teaspoon of salt per gallon) of water.

The salinity increases from surface to bottom. Salinity zones vary according to the rivers' discharge. During low flow, the tidal influence is felt further up the estuary and the higher salt content water extends much further up than during peak flow. Based on a classic mid-1960's study by Haefner, salinity zones were determined as follows. The fresh-water stretch (0-.5‰) began at the Bangor Dam and extended a distance of 3 km to 18 km downstream. The oligaline region (.6-3‰) extended beyond the freshwater section a distance of 3 to 10 km. The mesohaline region (3.1-17‰) reached as far upstream as Hampden and as far downstream as Bucksport. The polyhaline region (17.1-30‰) was the largest region. It could extend upstream beyond the Winterport Marina and almost extended downstream beyond Verona Island. Marine water greater than 30‰ was observed only as far upstream as Bucksport. Due to a large degree of stratification in the polyhaline region above 25‰, marine water was never observed in surface samples. From these salinity observations a high degree of stratification is noted in the lower estuary (downstream from the region under consideration), considerable mixing occurs between Verona Island and Bald Hill Cove, and near uniform conditions exist at the head of the estuary.

Estuary Salinity Diagram



Incomplete mixing of freshwater flowing over the surface of denser seawater forms a stable brackish layer. This sudden increase in density is known as the *pycnocline*. In the Penobscot estuary, this pycnocline usually extended upstream to Bucksport. However, during low flow it extended as far upstream as the mouth of the Marsh River. The pycnocline has considerable significance in analyzing the pollution of the estuary. Wastes discharged at the water surface above the pycnocline will not penetrate this density gradient. Consequently, two conditions result. The pycnocline protects the estauary bottom from pollution, but also reduces the volume available for waste dilution.

Temperature profiles closely approximated density observations. Below Bucksport, considerable vertical variation in temperature was noted. However above this point the vertical temperature variation seldom exceeded 2°C.

The water in the Penobscot is provided by more than 500 lakes and ponds and about a thousand streams. Some of these arise in rocky barrens on the highest slopes of Mt. Katahdin; others, with dark, stained water, begin as the drainage from small moss-covered bogs. Some streams flow from subterranean streams that break out at the surface as crystal clear springs. Each eventually contributes to the character of the river and the quality of its water.

In addition to the natural substances carried into the main stream, people add other materials. Timber harvesting, construction, farming, domestic and industrial sewage, impoundments, channels and similar factors change the character of the watershed and upset the natural nutrient balance, resulting in increased siltation, modify water temperature, decrease water transparency and in a host of other ways, change the river.

A river is not an independent entity. It is an integral part of a watershed that supplies it with water, nutrients, organisms, energy and people's myriad of pollutants.

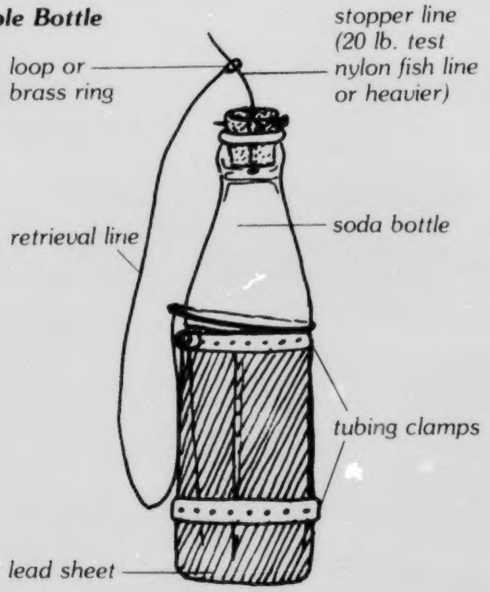
Anadromous fishes have been the most important species using the lower Penobscot River. Several thousand Atlantic salmon streams and many tributaries dwindled following construction of dams that blocks fish passage to many of the spawning grounds.

Today, due to dams partially or totally blocking passage and pollution causing areas of low dissolved oxygen in the estuary, none of the species are of commercial value in the estuary. By 1970's, the only commercial fishery in the Penobscot Estuary was for eels. Approximately 1500 pounds per week were taken by three fishermen from June to September 1971. A few alewives still run in the river, but none reportedly are taken commercially. Atlantic Sea-Run Salmon have returned to spawn in the watershed and are sought today by sportsmen and women from the Bangor Pool all the way to the Veazie Dam. Striped bass also occur and are occasionally taken by sport fishermen. Current, unpublished, data indicate little commercial activity in the river except a limited crab fishery below Bucksport.

Activity

Students can collect and analyze the approximate salinity of estuarine water very easily using home made equipment. Water for testing can be collected from bridges or by pleasure boaters. Water can be placed into clean stoppered "juice" bottles and kept for years. Salt determination will not change the water. *Do not* allow student to collect water from the banks of the river both for the *very severe* chance of drowning and because near shore samples are very unrepresentative.

Sample Bottle



Collecting bottles can be soda bottles with lead sheet added for ballast. Attach the sheet with tubing clamps and finish the device off with a rubber stopper with a nail through it. Use a one hole stopper (you can get one of the proper size from your local chemistry teacher) and thread your *heavy* nylon fish line through the stopper with a heavy needle. This line is used to remove the stopper and also retrieve the bottle.

As the stopper is removed under water it must be securely connected to the body of the bottle by a meter long slack line and a non-closing loop or better a brass ring.

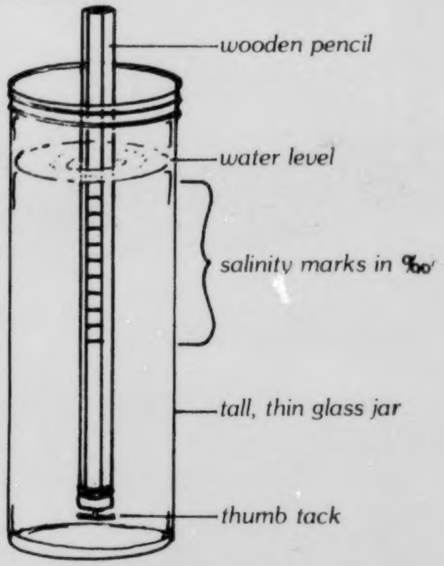
The bottle is a kind of remote opening collector that allows you to collect well below the surface. Lower it gently. When you are sure it is at the proper depth a sharp tug on the line will pull out the stopper which will catch on the loop or ring and the bottle will be secured by the line as it fills and is removed. Be sure your point of line attachment is well above the center point of the bottle or it will spill its contents as you pull it out of the water.

Test your bottle in a bath tub or better in a swimming pool to be sure it will sink easily when filled with air (if not add more lead) and that it both fills with water and returns filled after a sharp tug on the line.

The activity procedure can have your class test water gathered at various depths or at various locations along the estuary. Use local resources for wide cooperation in obtaining many different samples. Be sure each is labeled specifically as to where it was collected.

To test your water samples you will need a few new wooden pencils with eraser ends preferably painted white or light colors. The pencils will become hydrometers with the addition of a thumb tack into the eraser. The hydrometer is a floating measurer. That is, liquids that are light (less dense) will allow the hydrometer to float lower whereas heavy liquids (more dense) push the pencil hydrometer up higher. The device is used by placing the standard of comparison or the liquid to be measured into a clear tall container. The hydrometer is then added and the reading is made

Pencil Hydrometer



depending on how far the pencil sinks. When you start, you will need to be sure that your pencil does not bottom out in tap water nor float sideways in your most concentrated sample of salt water.

You should have your class make salt solutions for comparison and mark off their hydrometers in ‰ salt on the side of each with water proof pens. Pencils are highly variable so each needs to be individually checked for floating/sinking ability after its eraser end is weighted with a thumbtack.

Students should make up salt solutions by weighing salt in grams and measuring water in liters. A one part per thousand (1‰) solution has one gram per liter of tap water. Make standards every five ‰ from zero through 40 ‰. This will provide your class much needed practice in metric measurement. One set of standards for your class is sufficient. A box of salt will be all that you will need to purchase in addition to pencils and thumbtacks. Scrounging at home will provide the *numerous* jugs and "olive" jars.

This activity can be extended to include a detailed study of the salinity of any estuary including all of our major rivers or any small tidal stream. The larger the river or stream the more distance there should be between collecting sites. Students can compare such data as what fish are reported to be caught near collecting sites or what plants grow near shore. Shore bird life is also likely to change with salinity since the species of worms, snails, and mollusks they eat are likely to be limited to certain zones by salt content.

People's attitudes towards the river may also change as the "local" water becomes saltier or more marine. If you study the Penobscot estuary, you can use the Lower Penobscot River Area Map provided in the pocket as an overhead transparency to make a large map of the region for wall display. Youngsters can trace from the projected transparency directly onto large sheets or rolls of paper. As you conclude your study you may wish to have an "open house" for parents or for the school to show off your maps and charts along with the data you collected and the inferences you have made. Classes living distances from tidal rivers or streams might arrange to exchange water samples with a more "coastal" community.

F is for Fish:

The Atlantic Salmon

Teacher Advance Preparation:
This lesson could be taught by itself or extended into a content unit with the help of resources listed below. The life cycle is shown in the filmstrip ***A Right to Survive***. The life cycle and body parts drawings and question worksheets could be transferred to master sheets for student use. A poster size drawing of the body, made in advance, would be useful.

Objectives:
The student can briefly state the life cycle of the salmon. The student can draw and label the external features of salmon.

Method:
The teacher could review the life cycle and talk about the body parts (one way for young children, ***Salar Looks in the Mirror*** is suggested below). Students could name the parts on the worksheet, and take a quiz or two. The salmon quiz and parts diagrams are in the pocket, ready for reproduction.

Salar Looks in the Mirror

I'm good sized with average weight of 13 to 20 kilograms, though I can reach 85 kilograms.

After being in the ocean two years I might reach 75 to 82 centimeters in length.

If I'm a fresh run salmon, I am silvery with a darker back. If I am a mature male and in fresh water, I become mottled with a darker back and am a dull brownish red. As a mature male, I also have an elongated jaw with a hook at the tip of my lower jaw.

If I am a female, I am dull gray in color.

Now, let's see — not too bad looking at that! In fact, I'm rather handsome! But I don't look like a fish. What do I need? Please help me look like a fish. What do I need?

Students suggested a caudal fin. This and other parts were made from construction paper and taped on a volunteer. Other necessary parts were eye, gill cover, scales and the other fins (adipose, dorsal, anal, ventral and pectoral).

Though I am able to find the river of my birth by the magnetic field of the earth, by the stars and sun, by ocean currents and by the sense of smell, I can't count and don't really know how old I am.

However, people can tell my age. They can count the rings on my scales. This is something like counting the rings on a tree to tell how old it is. The rings on scales tell other things too.

Did you know that no matter how large I grow, the number of scales does not change? These solid, circular plates grow along with me. They will also tell you my periods of slow growth in the winter or in poor feed situations and my spurts of fast growth in the summer. In fact, my life history is recorded on these scales. *Worksheet* — drawing of ***Salar*** — students label different parts of the Atlantic Salmon and check work together.

The above lesson is one of many for the teacher interested in the king of the fishes. Several fine resources are available and easy to obtain. A number of books for young readers are well worthwhile.

Dillon, Wallace. ***Salmon,*** Chicago: Follett Publishing Co., 1962.

Gilhen, John. ***The Fishes of Nova Scotia's Lakes and Streams,*** Halifax: Nova Scotia Museum, 1974.

We highly recommend the learning materials from the International Atlantic Salmon Foundation for use in secondary classrooms. These materials, entitled ***Salar: The Story of the Atlantic Salmon*** include the following:

A 76 page book which looks at the Atlantic Salmon through the perspectives of history, geography and science. The book, available in hard or soft cover contains over 80 pictures (40 in full color) as well as many maps, charts, graphs and diagrams.

A color filmstrip with accompanying script and cassette tape entitled: ***A Right to Survive.*** The filmstrip and tape complements the book and covers the life cycle of the Atlantic Salmon, the effects of man on the species and conservation efforts.

A ***Salar*** simulation game which features a journey through the life cycle of the Atlantic Salmon.

A teacher's guide which has been prepared by teachers who have used the materials in Eastern Canada and Northeastern United States.

These materials are available by writing:

The International Salmon Foundation
PO Box 429
St. Andrews, New Brunswick
Canada EOG 2X0

or

100 Park Avenue
New York, New York 10017.

Hayes, Will. ***About the Biggest Salmon.*** Chicago: Melmont Publishing Inc., Chicago, 1961.

Phelege, Fred. ***Red Tag Comes Back.*** New York: Harper & Row Publisher, 1961.

Wooding, F.H. ***Canada's Atlantic Salmon.*** Ottawa: Department of Fisheries, 1962.

And any of the many fine children's books on oceans, rivers, and fishes.

The State of Maine Department of Inland Fisheries and Wildlife offers information on the Maine Atlantic Sea Run Commission in Bangor and reprints of articles which have appeared over the years in the Department's publication, ***Maine Fish and Wildlife.*** Write to:

Maine Department of Inland Fisheries and Wildlife
Augusta, Maine 04333

The Fisheries and Environment Department of the Canadian Government provides a series of Fisheries Fact Sheets; the one on *The Atlantic Salmon* is useful. It may be obtained from:

The North American Salmon Research Center
St. Andrews, New Brunswick
Canada EOG 2X0

They also offer publications on their genetics and culture program. The research center is a cooperative program of the government of Canada, the International Atlantic Salmon Foundation, and Huntsman Marine Laboratory.

Excellent resources are available from:

The International Atlantic Salmon Foundation
100 Park Avenue
New York, New York 10017

or

Box 429
St. Andrews, New Brunswick
Canada EOG 2X0

They include a classroom kit ***SALAR*** containing 30 copies of ***Salar: The Story of the Atlantic Salmon,*** 5 copies of games — **The Salar Life Cycle Game,** 1 filmstrip/cassette, and a teacher's guide. The unit is multidisciplinary and parts may be purchased separately. It is planned for grades 7-9 but may be successfully geared for younger learners. For Grades 5-6, the Foundation offers the Atlantic Salmon Kit; it includes leaflets for student use (covering 8 major salmon topics), two board games and several word games, posters and a 20 page teacher's guide. Also available, a small booklet *Atlantic Salmon Facts*. These materials are superb and highly recommended.

Answers to Atlantic Salmon Worksheets

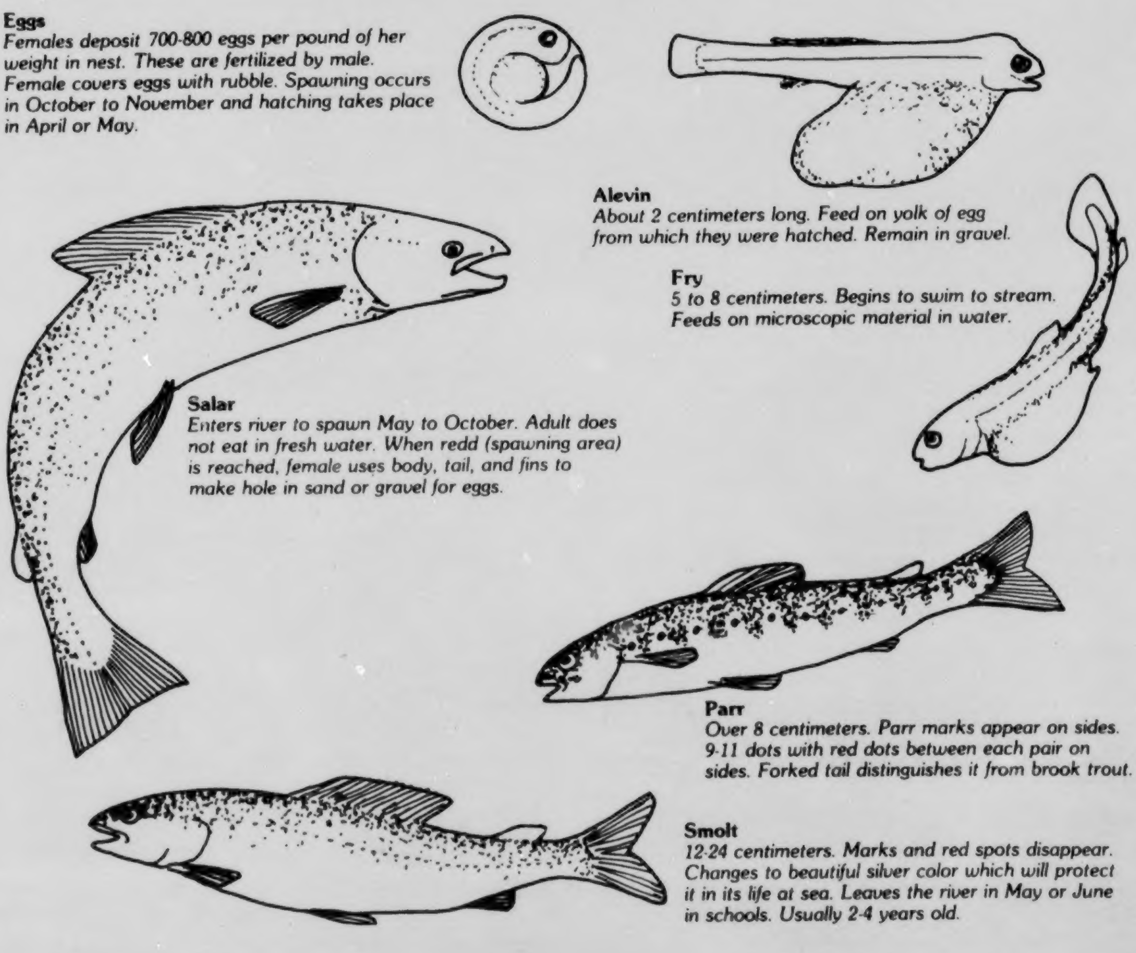
1. adipose fin
2. dorsal fin
3. lateral line
4. gill cover
5. pectoral fins
6. ventral fins
7. anus
8. anal fin
9. caudal fin

1. b-estuary
2. c-several times
3. a-grilse
4. a gravel bottom
5. b-lateral line
6. c-scales
7. c-scales
8. a-migrate
9. a-spawning
10. a-2

Answers to Salar Quiz

1. redd
2. 700-800 eggs
3. alevin
4. parr
5. forked tail
6. smolt
7. kelt
8. grilse
9. long, hooked
10. pollution, over-fishing, dams without ladders
11. gill net, trap
12. regulations, hatcheries, fishways

Life Cycle of Atlantic Salmon



Eggs
Females deposit 700-800 eggs per pound of her weight in nest. These are fertilized by male. Female covers eggs with rubble. Spawning occurs in October to November and hatching takes place in April or May.

Alevin
About 2 centimeters long. Feed on yolk of egg from which they were hatched. Remain in gravel.

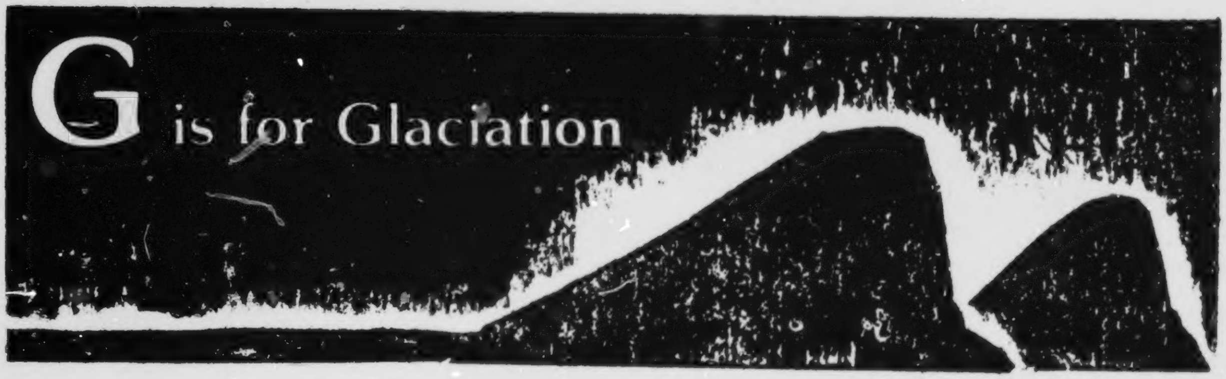
Fry
5 to 8 centimeters. Begins to swim to stream. Feeds on microscopic material in water.

Parr
Over 8 centimeters. Parr marks appear on sides. 9-11 dots with red dots between each pair on sides. Forked tail distinguishes it from brook trout.

Smolt
12-24 centimeters. Marks and red spots disappear. Changes to beautiful silver color which will protect it in its life at sea. Leaves the river in May or June in schools. Usually 2-4 years old.

Salar
Enters river to spawn May to October. Adult does not eat in fresh water. When redd (spawning area) is reached, female uses body, tail, and fins to make hole in sand or gravel for eggs.

G is for Glaciation



Periods of glaciation, or active erosion and deposition by huge masses of ice, have occurred from time to time in geologic history. The first great ice sheets which left their record in the rocks were formed in the Pre-Cambrian, but, because of the long time span since the early ice masses melted, most of the record of their distribution and extent has been removed.

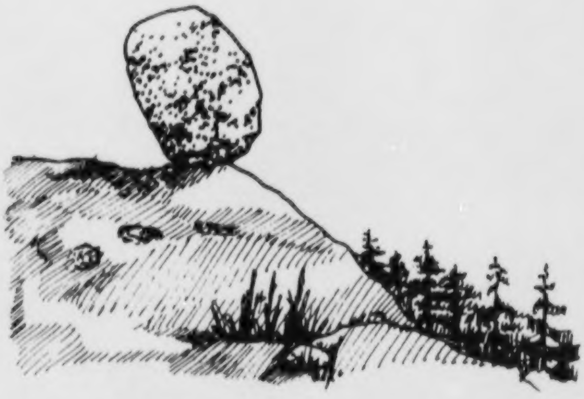
In Permian or late Pennsylvanian time, much of the southern hemisphere was covered with ice in probably the greatest period of glaciation the world has experienced. Much of the record of this ice advance remains as mute testimony to the endurance of glacial deposits.

Much more recently, in the Pleistocene ending about 12,000 b.p., most of Europe, northern Russia, Canada, and the northern United States were subjected to intense glaciation. The effects are well preserved in surface deposits, and the last retreat of the ice masses was so recent that many students of the subject feel we should not consider our present existance as postglacial, but rather as occurring between ice advances.

Any area where the amount of precipitation freezing in a year exceeds the amount of melting will be the site of glaciation if the excess continues long enough. The ice sheet which develops erodes indiscriminately. Unlike wind, water, and waves, which are delicately selective in materials they erode, ice masses make no distinction between resistance of materials or their structural relationships. The advance of an ice sheet may be compared with the advance of a mighty bulldozer; what can not be moved bodily can be driven over and subjected to attack from above.

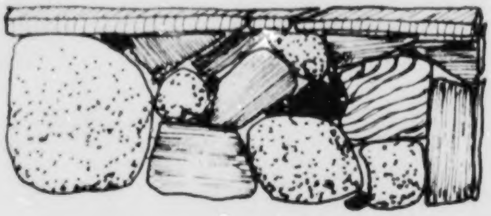
The main erosive effect of a continental ice mass is, thus, a rounding off of hills and a subduing of topography. Stream patterns become deranged with many valleys filled and new ones formed. Immense quantities of material are picked up along the sides and bottoms of the ice mass and deposited many miles away. Besides the immediate erosional and depositional effects, continental glaciation may have far-reaching repercussions. It is estimated that the water tied up in ice during the last great glacial epoch must have resulted in a world wide lowering of sea levels amounting to perhaps 600 feet. Streams all over the world must have been rejuvenated by the increase in their gradient.

Near home, another secondary effect of the last glaciation was a noticeable down warping of the crust where the ice mass adds to its weight. The surface may have been depressed several hundred feet, and has only half returned to its former position. The result is that the Maine coast is a shoreline of submergence with deep water immediately off the continental shelf and the formation of a large inland sea, "the Gulf of Maine," from the continental slope inland for about 200 miles to shore.



Field Trip to a Stone Wall and Erratic

Objectives:
- To study the rock types in any stone wall.
- To examine for striae.
- To make students aware of how they were put there.
- To show how farmers have been effected by glaciation.
- To show why Maine has limited top soil.



Preparation:

a. find a suitable rock wall preferably with a large erratic nearby.

b. After obtaining permission to study the wall, familiarize yourself with the immediate area.

Activities:

a. Photograph the trip.

b. Observe the area: note the families of rock in the wall.

c. Note the mineral composition of the rock.

d. Have students make note of any signs of glaciation.

e. Examine carefully the erratics.

Field Trip Follow-up:

a. Show pictures or slides of the field trip and let the students discuss or write a story about it.

b. Have students discuss how glaciation has affected the lives of people that have lived in Maine (e.g. from the precontact period to present day).

c. How were erratics probably carried or moved by the glaciers?

d. Would the area visited by the field trip have any remote similarity to the way some of the bottom of the Gulf of Maine may look?
(Encourage a discussion on the term "Lobster Bottom.")

e. Have students reflect on where other erratics may be found.

f. Have students look up other facts and pertinent data on erratics, moraines, "Lobster Bottom," eskers, etc.

Map Study Exercise

Objectives:

- To study the possible paths of glacial ice.
- To show the affect of changing sea levels in Maine.
- To show how glaciation has affected Maine's Coastline.
- To study the affect of glaciation on the Gulf of Maine.

Preparation:

a. Have students secure any number of topographic maps of the State of Maine, and the Gulf of Maine.

b. Have some students secure some "State of Maine" highway maps.

c. Obtain a number of colored pencils.

Activities:

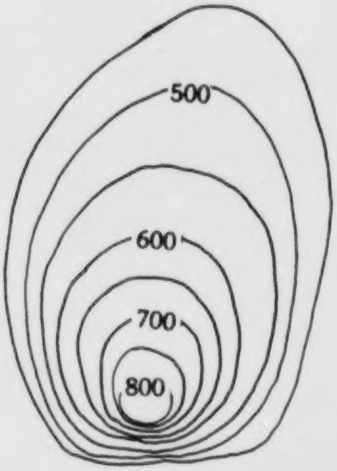
a. With colored pencil, shade in all areas on the map below the 200 foot contour level. (The approximate level of the Gulf when the Gulf filled up and ran back over the land.)

b. Study the general elongation of most lakes, bays, etc., and the direction of most of the larger rivers and streams.

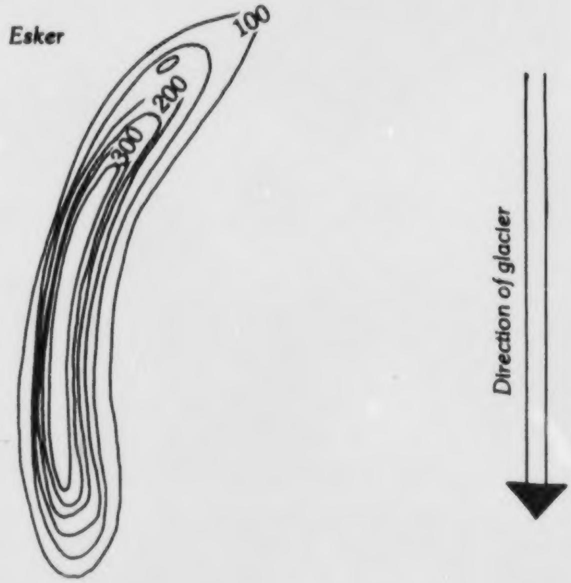
c. Study the area where the seashore would be if the sea levels dropped 200 feet because the water was locked in glacial ice.

d. Using contour levels as a guide, determine the general shape of the floor of the Gulf of Maine. (Is it fairly flat, full of submarine canyons, mountainous, etc.)

Roche mouton



Esker



Map Study Follow-up:

a. Have students look up facts and other pertinent data on the topography of Maine and the Gulf of Maine.
b. Is there a relationship between the 200 Mile Limit and the depth of the Gulf of Maine?
c. Is there a relationship between the type of bottom and the type of fishing by Maine fishermen?
  — What are 'Banks'?
  — What are 'Ledges'?
d. Is there evidence of glaciation and its direction on the map?
e. Would the area in which you live been affected by rising sea levels?

Maps

1. Surficial Geologic Maps and Reports for Maine
   Critical Areas Program
   State Planning Office
   189 State Street
   Augusta, Maine 04333

2. Bedrock Geologic Map #26 (Bastin 1906, U.S.G.S. Folio 158); #20 (Moench 1976, U.S.G.S. J-605)
   Maine Geological Survey
   Department of Conservation
   AMHI Ray Building
   Augusta, Maine 04333

3. Topographic Maps
   U.S. Geological Survey
   Reston, Virginia 22092
   And most sporting goods stores.

4. ***Maine Atlas and Gazetter***
   Book Stores
   Most Maine stores

5. New England Intercollegiate Geological Conference Guidebook
   A-3 ***Sedimentary and Slump Structures of Central Maine***
   B-3 ***Stratigraphy and Structure of Central Maine***
   Department of Geology
   725 Commonwealth Avenue
   Boston, Massachusetts 02214

6. Marine Chart of the Gulf of Maine: see information at the end of letter Y (Yacht Race)

Films

The Earth Beneath the Sea
(McGraw-Hill/Lamont-Columbia) 1967. 22 min. Color. Excellent example of film showing what scientists really do — in this case deep ocean marine geologists.

The Earth: Coastlines
(Coronet) 1970. 11 min. Color. Explains the role of waves in the creation of sea terraces, cliffs, beaches and sand bars. Also discusses coastlines of submergence and emergence.

The Earth: Its Oceans
(Coronet) 1960. 12½ min. Color. Examines currents, sea bottom topography, sediments, waves, tides, and man's relationship to the sea. Earth science oriented. Spends little time on sea life. Available from UMO film service (M1768)

How Level is Sea Level
(Encyclopedia Britannica) 1970. 13 min. Color. Shows various factors affecting level of the oceans — differences in salinity, temperature, air pressure and winds.

Oceanography: Science of the Sea
(BFA) 11 min. Color. The instruments and techniques used to study the ocean and its floor are illustrated. Information gathered using this equipment describes the physical characteristics of the ocean floor and the earth's history.

What's Under the Ocean
(BFA) 14 min. Color. Illustrates the methods, equipment, and vessels used to study the ocean and its floor. Shows features of the Atlantic and Pacific oceans.

Distributors

Woods Hole Oceanographic Institution
Woods Hole, MA 12543

Modern Talking Picture Service
2323 New Hyde Park Rd.
New Hyde Park, N.Y. 11040

UMO Film Services
Instructional Systems Center
Shibles Hall
University of Maine
Orono, Maine 04469

H is for Heritage of the Sea

Maine has a proud marine heritage. Well before the time of the early European explorers and traders, Native Americans travelled the coastal and inland waterways of the state in birch canoes and dugouts. The first white people arrived in ships and early colonists in the state came looking for lumber with which to build vessels. Maine's finest hours in her history revolved around the age of sail when nearly every coastal town was engaged in boatbuilding and fishing and practically every inland riverway saw log drives of the great lumbering operations of the north woods.

Fortunately, a fair amount of Maine's maritime heritage has been preserved in story, song and artifact. The Maine Marine Museum at Bath and the Penobscot Marine Museum at Searsport, house excellent collections of models, navigational instruments, ships logs, restorations and shipbuilding tools. The Maine State Museum in Augusta has in its possession a section of the fully rigged ship ***St. Mary***, built in Phippsburg in 1889-90 and wrecked on the Falkland Islands in 1890. The work songs of sailors, called sea chanteys, have been collected by people such as Johanna Colcord in her book ***Songs of American Sailormen***. Contemporary Maine recording artists like Gordon Bok of Camden and Bill Bonyun of Westport Island have put on record albums traditional and not so traditional songs of the sea. (Bok's albums are available from Folk Legacy Recordings, Sharon, Connecticut; Bonyun's from Heirloom Records, Wiscasset, Maine.) Traditional and modern sea music is the specialty of ***Schooner Fare***, a trio consisting of Chuck Romanoff, Steve Romanoff, and Tom Rowe. Inquiries about their albums should go to Outer Green Music Company, P.O. Box 8012, Portland, Me. 04104. Folklore of the sea that has been carefully collected and written down can be found in such books as ***Charley York, Maine Coast Fisherman*** (written by Harold Clifford, published by International Marine Publishing Company, Camden, Maine).

We should take the opportunity to celebrate Maine's colorful maritime heritage. In the following sections are just a few ideas you can try.

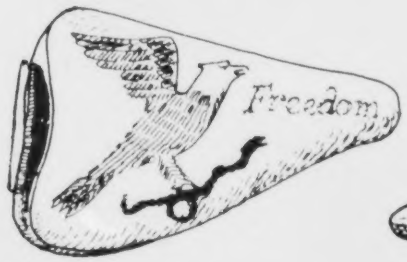
Scrimshaw

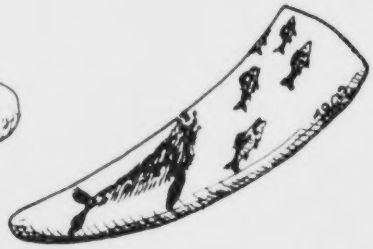
During the long voyages, sailors would carve designs or scratch pictures into whalebone as a pastime. This is known as scrimshaw. Usually scrimshaw pictures were of what was available to sketch; we therefore have a good idea of what a sailor thought of and appreciated most during those years at sea. Often pictures were of other ships, sailors or the wives left back at port. Today, scrimshaw items are very valuable.

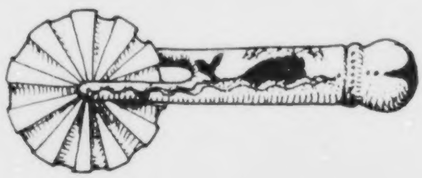
Since whales are protected by U.S. law, new whalebone and whale products are not permitted into the country. Students may make some similar scrimshaw items, under supervision, by the following process:

a. Thoroughly wash and clean smooth beef bones (ribs are good).

b. Soak the bone in chlorine bleach for half-hour to bleach and disinfect it. Rinse off.







c. After the bone dries, lightly sand it with fine sandpaper in the direction of the grain.
d. With a pencil, sketch a nautical scene on the bone.
e. Using an artist's scribe or a sharpened nail, scratch the desired image onto the surface of the bone. Wear safety goggles and one glove for protection during this procedure.
f. Rub over the image with ink on a Q-tip to color in the lines. The black should wipe off the unscratched surface of the bone.

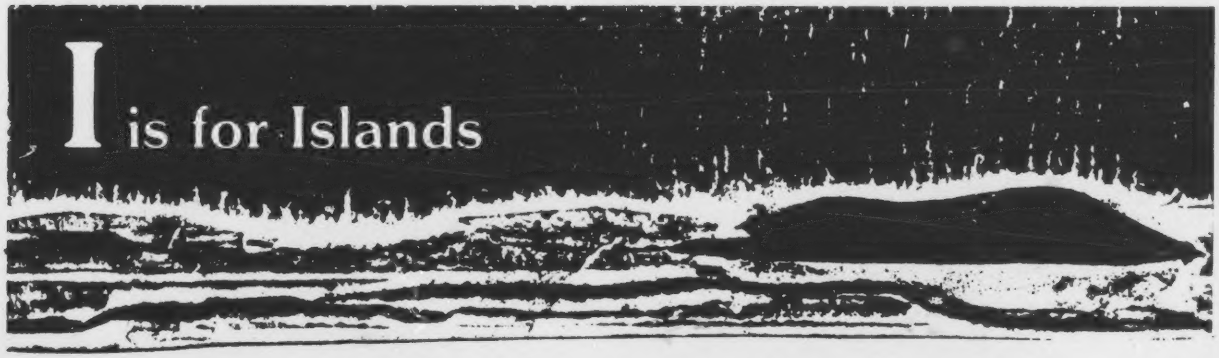
This project can also be done with the inside surface of hard shell clams (quahogs) or with plaster of paris, as follows:

Mix plaster of paris with water. Drop small spoonfuls on wax paper. When sufficiently hardened, remove from paper. These will be fairly round. Use nail to sketch design — ship, whale, etc. If a pendant is desired, carefully make a small hole at the top with a nail. Use fine brush and black tempera paint to paint over lines of design. Rub firmly but carefully over entire piece to smear paint. String yarn through hole for hanging.

Weather Lore

Predicting the weather while at sea has always been of major importance to mariners. Over the years, sayings, almost a form of poetry, have been handed down from one generation of sailors to another for use in predicting the weather. Try these sayings as they apply to the weather in your area and see if they hold true most of the time.

Saying	*Meaning*
Wild Geese, Wild Geese, Gangin' Out to Sea All fine weather It will be.	Sea birds, like geese and gulls, tend to come inland when a storm is brewing or coming at sea. They return to the feeding grounds or migration paths only when there is clear weather expected for an extended period of time.
Red Sky at morning, Sailor take warning, Red Sky at night, Sailor's delight.	Red sunsets generally predict fair, calm weather for the following day. Red sunrises generally herald a coming change for the worse in the day's weather.
Mackerel Skies and Mare's Tails Make tall ships Carry low sails.	Mackerel skys are alto cirrus clouds and mare's tails are cirrus clouds. These formations herald thunderstorms, rain and wind.
If clouds look as if Scratched by hen, Get ready to reef your *topsails then.*	Cirrus clouds, or a streaked sky indicates high winds and showers.



I is for Islands

The coast of Maine, some 5,100 total kilometers (3,300 miles) of coves, bays and peninsulas, is fringed with hundreds of large and small islands. These islands are the remains of glacially deposited ridges, parts of which were left high and dry after rising sea levels drowned out the lower areas. Today some of these clouds are still uninhabited, while islands like Mt. Desert are quite populated, especially during the summer. Some, such as Monhegan and Deer Isle, are important to Maine's tourist trade; others have been set aside for wildlife preserves, such as Machias Seal Island.

Many debates have risen over what should be done to Maine's islands. Review boards (such as the Board of Environmental Protection and the Land Use Regulation Commission) are established to help analyze the island resources and hand down decisions, called *orders*, on the island's future. Their decisions are based on federal, state and territorial laws that regulate the island, the potential environmental and economical effects that changes may have upon the island, and the usefulness the island has to the state and local communities in its present condition versus the proposed condition.

Activity

Below is a description of White Cap Island off Maine's coast. White Cap Island is a hypothetical island designed around several natural resources; geology, shoreline types, ground water, soil types, vegetation, wildlife and scenic value. This island is being considered for some type of development. The following organizations have all expressed interest in using the island for their specific type of development: Audubon sanctuary developers, artist colonies, seasonal campground developers, hotel/resort developers, housing developers, fisheries builders, paper company foresters, and wildlife preservationists.

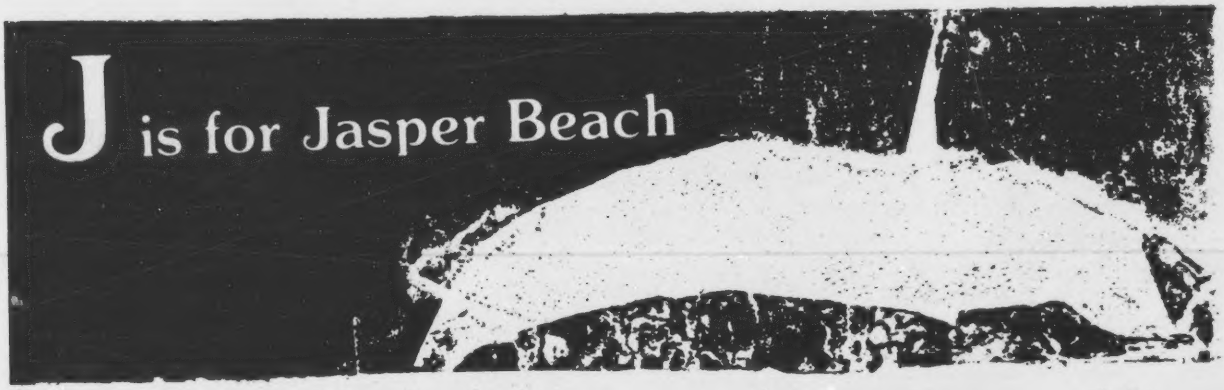
1. Pass out the description and maps of White Cap Island given in the pocket section of this unit.
2. Establish an odd numbered review board to listen to and decide upon the practicality of the above organizations views. You, as teacher, may decide to be the review board and rate the students on their presentation.
3. Divide the class into groups (1-4 to a group depending on the size of the class) and assign each group the responsibility of presenting the views of one of the above organizations. You may decide to make up or change any organizations depending upon the interests of the class.
4. Have students complete the solubility of soils chart below, placing descriptors (good, fair, poor, very poor) for the quality and use of the seven types of soils. Students can use this chart to help determine the potential use of the island. The different soil types are given in the 'Soil Types' section in the pocket section of this unit.

Solubility of Soils Chart

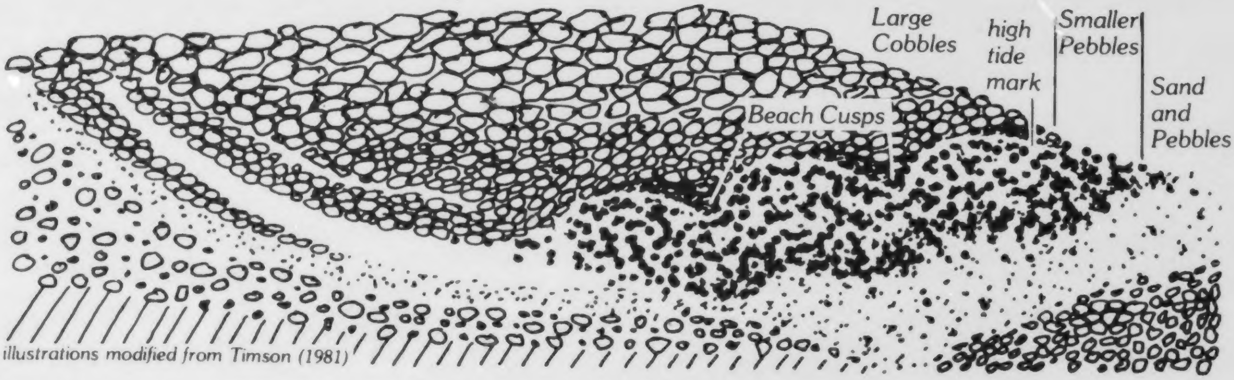
Soil	*Houses with basement*	*Recreation Cottages with no basement*	*Wilderness' Tent sites*	*Septic sewage disposal*	*Privy unsealed*
1					
2					
3					
4					
5					
6					
7					

5. During a 1-2 hour session have each group present their views to the review board. Props (maps, graphs, charts, pictures, etc.) are encouraged.
6. Later that day, or in the near future, have the review board give its decision. Discuss the reasoning behind the decision. What might have been done differently? Will any organizations want to appeal the decision? Why?

J is for Jasper Beach



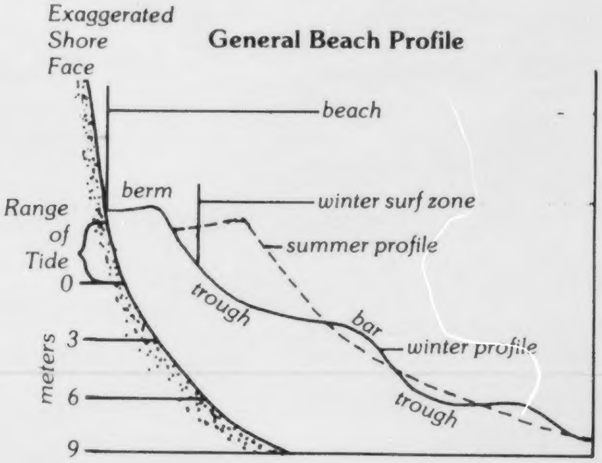
Jasper Beach is a rocky shore area off the Starboard Road in Machiasport. It is unique in Maine in that it is composed to some extent of pure jasper stones. Jasper, a name given to the mineral chalcedony, a common form of quartz, runs in shades of red from light pink to almost black. Those of you close by might have the opportunity to take a field trip to Jasper Beach; it is a beautiful and fascinating place to visit. Not only can your students study the color variations in the jasper pebbles, but they can also learn some general principles of marine geology. Beach deposits consist of hard mineral grains ranging in size from the fine sand through pebbles, all the way to large cobbles. Because the turbulence of the surf is great, the fine particles of silt and clay cannot accumulate on the beach but are carried offshore where deeper, quieter waters allow them to settle. Examine the sizes of the beach deposits. Where are the largest cobbles and pebbles located? The smallest? Generally speaking, waves lose their energy as they travel up the beach and can only carry lightweight particles. However, storm waves will pick up larger rocks, transport them up the beach face and leave them stranded as part of the "shingle beach." The size of the particle is also related to the slope of the beach: fine sand forms beaches with slopes of low angles; coarse sand creates a steeper slope while cobbles are responsible for the very steepest slope. How does the slope of Jasper Beach appear to you? How does it compare with a sandy beach? Also notice the



illustrations modified from Timson (1981)

beach cusps which develop parallel to wave motion. These evolve as a series of U-shaped depressions along the beach with "horns" pointing seaward. Cusps have long been a puzzlement to coastal geologists and none of the dozens of explanations as to their formation is completely satisfying. Generally speaking, they seem to be the results of waves with energies somewhere in between erosional and depositional. In other words, when a wave does not have enough energy to erode the beach but has too much to deposit sediments, it seems to form cusps.

General Beach Profile



Since most of you using this guide will be unable to visit Jasper Beach with your students, let us now take a look at some ways you can study marine geology in your classroom.

Activities

Beach Models

Have students make a clay model of the shoreline using the geologic map of Jasper Beach in the pocket. Include some of the ocean bottom in the model. Place the model in a sink or large dishpan and add water until the "ocean bottom" part of the model is covered with water. This is how the shoreline looks today. Next, pour out all the water. This is approximately how the shoreline looked when much of the ocean's water was frozen into the glaciers of the Ice Ages. This is called an emergent shoreline. Finally add enough water to cover some of the areas that are land today. This is what might happen to sea level if the polar ice caps melted and represents a submergent shoreline.

To study how different sized particles are carried by water, obtain a variety of sediments: clay, fine grained sand, coarse grained sand, pebbles. Put each size into a separate plastic dishpan, add water to nearly the top of each pan and stir the sediments vigorously with wooden spoons or sticks. Have students time or observe how long it takes for each size of particle to stop moving in the water. You can see that as the water movement loses energy, the larger particles "fall out" and stop moving more rapidly than the smaller particles.

Erosion

If you have a ripple tank in the Science Department of your school, you can set up a "beach" of sand or pebbles at one end and demonstrate the effects of wave erosion. By using a variety of sizes of sediments and waves generated, you can demonstrate the relationships between wave height, beach sediment size and erosion.

Some excellent resources for upper high school students that discuss geological processes on beaches are:

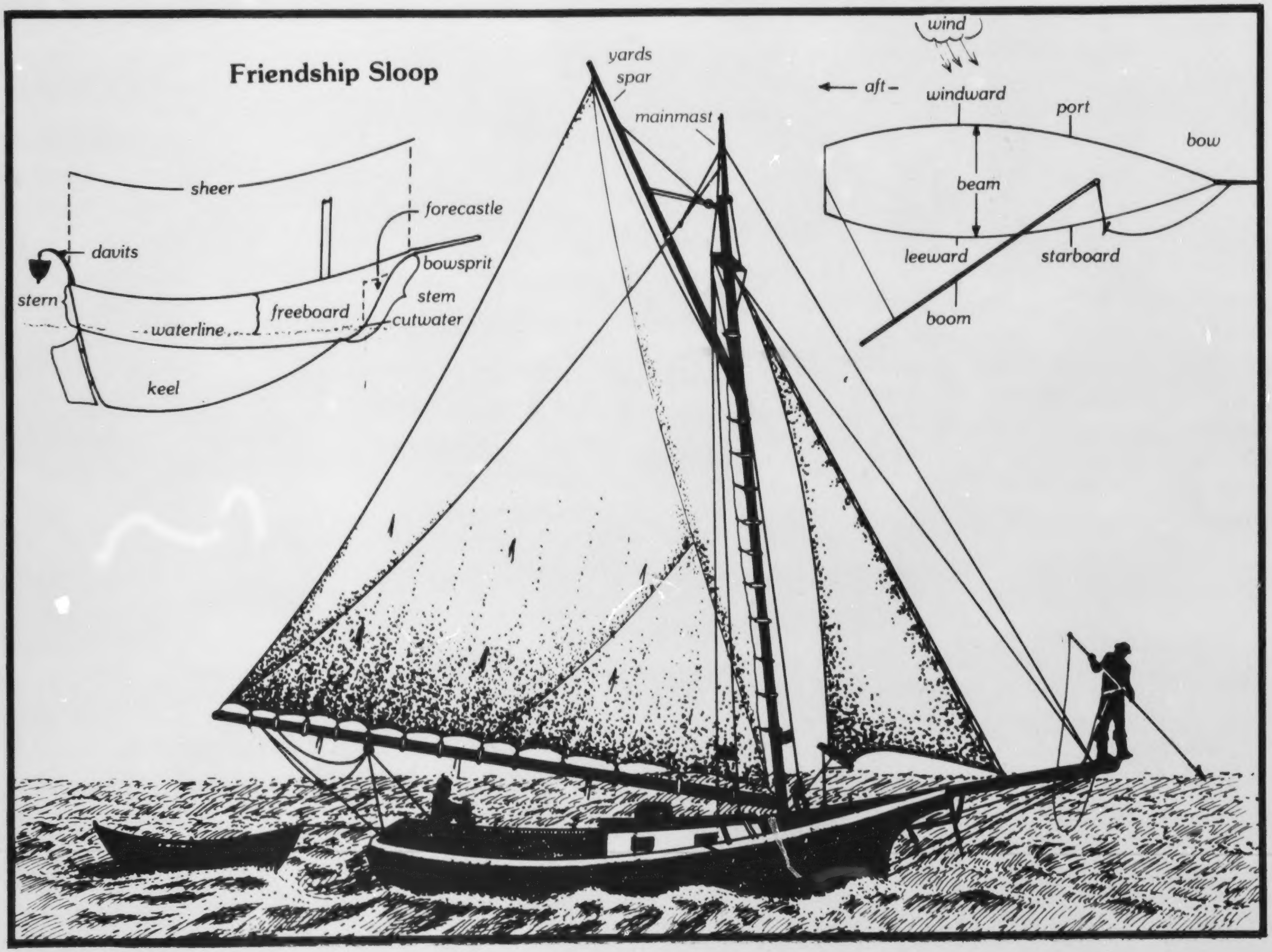
Bascom, Willard. ***Waves and Beaches.*** Science Study Series, Anchor Books, Doubleday & Company, Inc. Garden City, New York, 1964.

Project COAST "Sea Floor Spreading" Activity available on loan from Northern New England Marine Education Project.

Ramsey, William, Clifford Phillips and Frank Watenpaugh. ***Activities for Modern Earth Science***. Holt, Rinehart, & Winston, Inc. New York, 1969.

Scientific American. ***Continents Adrift and Continents Aground.*** W.H. Freeman and Company. San Francisco, 1976.

Turekian, Karl K. ***Oceans***. Foundations of Earth Science Series, Prentice-Hall, Englewood Cliffs, New Jersey, 1968.


Friendship Sloop
sheer
forecastle
davits
bowsprit
stern
stem
freeboard
waterline
cutwater
keel
yards
spar
mainmast
wind
aft
windward
port
bow
beam
leeward
starboard
boom

K is for Keel and Ship Terminology

This information is intended to familiarize students with the major features of historic vessels particularly sailing vessels. Included are a brief vocabulary list, a description and an illustration for rigging types. Our entry for K ends with a rigging activity.

Ship Terminology

aft:	rear direction on ship
beam:	breadth of ship
boom:	lowest wooden beam used in schooner rigging
bow:	forwardmost part of ship
bowsprit:	boom extending from bow of vessel
cutwater:	where ship's bow meets water
davits:	small cranes from which lifeboats hang
forecastle:	storage area in bow of vessel
mast (main, fore, mizzen):	upright vertical poles from which sails hang
port:	left (directional)
sheer:	horizontal curvature of a ship's deck
spar:	crosspiece from which sails hang from masts
starboard:	right (directional)
stem:	cutwater edge of bow extending from bow sprit to keel
stern:	rearmost portion of vessel
yards:	spars
windward:	side of vessel the wind is hitting
leeward:	side of vessel not in path of wind
freeboard:	amount of hull between deck and waterline
keel:	midline of ship upon which ribs are fastened
oar:	long rowing paddle for propelling small craft

About Sails and Rigging

Not all sailing vessels were rigged in the same manner. Specific sailing ships were designed for specific purposes, be it a Clipper ship, freighting Downeaster, or whaler.

On sailing vessels, the first mast nearest the bow is the *fore mast*. The mast or masts following are the *main masts*. The last mast on a vessel is the *mizzen mast*.

Sail plans can designate over thirty separate sails on a single vessel, but we can classify sailing vessels by the mast and yard arrangements (a *yard* is the wooden crosspiece from which sails hang on a mast). There are two major types of sail plans; square rigs and schooner rigs. Square rigs are four-sided canvases (though not always exactly square), schooner rigs are large triangular canvases. The combinations of these rigs as they are hung from the masts determine the type of ship.

Not all sailing vessels were "ships." *Ship* rigging implies that three or more masts must all be square rigged. Two masted vessels with square rigging are called *brigs*. A vessel with at least three masts, the fore and main masts square rigged, and the mizzen mast schooner rigged, is a *bark*. Vessels with at least two masts, all of them schooner rigged, are simply *schooners*, no matter how large. Mast plans for various vessels are given in the pocket.

While not all sailing vessels or steam powered vessels are ship rigged, we still use this term "ship" to identify most large vessels as a convenience.

Activity

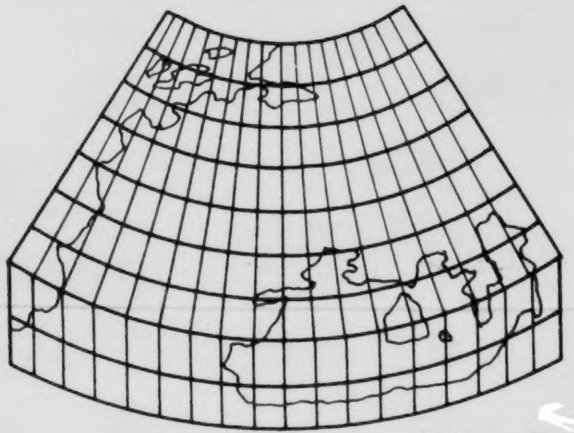
Equip blocks of wood with various sail arrangements similar to those in the picture. Compare how these riggings might be used on different size vessels for speed and manuverability. Try modifying the blocks of wood for speed and stability. Why must the keel (bottom) be weighted when wind catches the sails? This is called ballasting. Sailing ships would carry granite ballast to prevent capsizing. Try rigging sails to roller skates and use them in the parking lot on windy days.

A good reference on ship models is:
Weire, Harvey. ***Ship Models and How to Build Them***; Thomas Y. Crowell Co., N.Y. 1973.

You will find more activities of this sort in the NNEMEP Unit, ***What Is Our Maritime Heritage?***

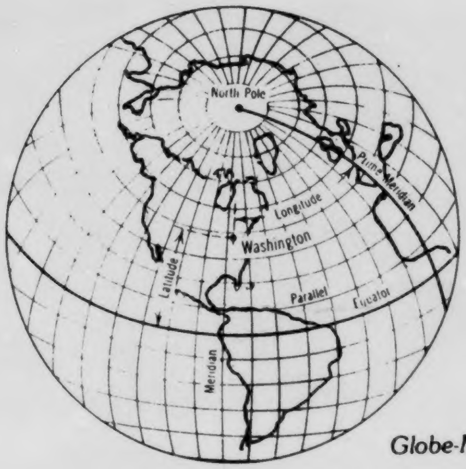
L is for Longitude and Latitude

The concepts of latitude and longitude were first introduced to the world by the Roman astronomer, Ptolemy, about 150 A.D. His contribution opened up Roman geographic knowledge and enabled a projection of the globe to be presented in map form. Ptolemy measured latitude by noting the angle the pole star makes with the vertical and devised a primative way of measuring longitude from the time required for sea voyages (see Ptolemy's Map). Captain James Cook (1728-1770), was the first explorer to use proper instrumentation to determine longitude and latitude accurately.



Ptolemy's Map

Since the time of Ptolemy, locations on earth have been specified by giving their longitude and latitude. Globes are provided with a grid of meridians, circles running north-south through the poles, and parallels, circles running east-west parallel to the equator. The longitude is the angular distance, east or west, from the prime meridian, which passes through the Royal Observatory of Greenwich, England. The latitude is the angular distance between the parallel and the equator. The meridians and the equator are called great circles. A great circle is formed by the intersection of the surface of the map with a plane passing through its center (see Globe Map). Parallels other than the equator, since their planes do not pass through the center of the earth, have smaller diameters.



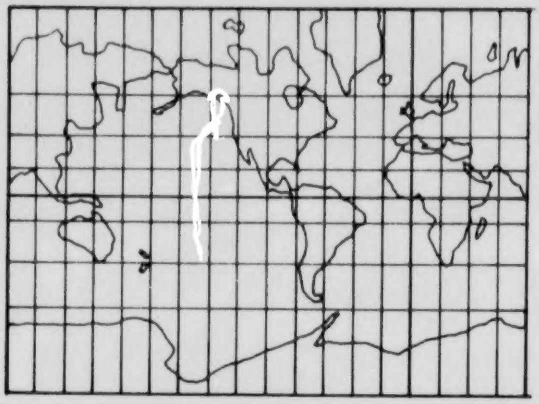
Globe-Map

Below is a scale that shows the latitude distances in kilometers and nautical miles. Since a degree of latitude on earth always has the same length regardless of the latitude, a navigator can use this scale as a measure of length. Note that since the earth is slightly flattened at the poles and is not a perfect sphere, a degree of latitude has a slightly different length at different locations.

Length of 1° Latitude

Latitude	Kilometers	Nautical Miles
0	110.567	59.701
30	110.848	59.853
60	111.414	60.159
90	111.699	60.313

The Mercator projection is used as an equatorial projection which, in Gerardus Mercator's (1512-1594) own words is simply "a new proportion and a new arrangement of the meridians with reference to the parallels," that is, a conventional grid. In a Mercator project, as one moves toward the poles, the scale of the map keeps increasing. Since at the pole a degree of longitude has zero length, the



Mercator Projection Map

scale of the map there becomes infinite; therefore it is not possible to plot the pole on a Mercator projection.

Activities

From the longitude and latitude exercise map provided in the pocket section, have students label and number the degrees of longitude and latitude. Once labeled and numbered, students can draw in the longitude and latitude parallel lines. Refer to letter Y in this teacher guide for a chart of the Gulf of Maine that shows the values of the latitude (vertically) and longitude (horizontally). The map is now in the form of a 'grid'. Students should be able to locate different regions on the grid map (Cape Cod, Portland, Mount Desert Island) by using degrees of longitude and latitude. (Cape Cod 41°-42° North Longitude, 70°-71° West Latitude; Portland 43°-44° North Longitude, 70°-71° West Latitude; Mount Desert Island 44°-45° North Latitude, 68°-69° West Latitude).

M is for Marinating Your Classroom

*This article originally appeared in **Current**; and was reprinted with permission.*

by Les Picker and John Butzow

As staff members of marine education curriculum projects, we often have teachers at workshops asking how they can make their own marine education units. While there is no simple answer to this question, it has occurred to us that some very basic, simple procedures can be effectively used by interested teachers to create exciting, meaningful and educationally valuable marine education experiences for youngsters.

The Major Obstacle

The majority of teachers today recognize the need for citizens to be informed about our world of water. These teachers, along with the ones who become converts at workshops, are unfailingly enthusiastic about aquatic education and its potential. Here is an exciting, fascinating, and inherently motivating topic for their students. One would have to think awhile to come up with a topic of greater significance for the future well-being of our water planet.

Unfortunately, this enthusiasm is soon dampened by what is initially seen as a problem. Most elementary and non-science trained secondary school teachers have little technical marine information. They see this as an obstacle.

However, we have found it to be more perceived than real. Teachers can and *do* have the expertise to design their own marine education units, tailored for their own individual classes.

A Definition of Terms

There are two terms which are bantered about nowadays and should be defined for our purposes.

The first is "multidisciplinary," a concept as confused and misunderstood as the word is long. When we refer to a multidisciplinary unit, we simply mean a unit designed to include as many subject area disciplines as possible. For example, a fifth grade teacher wishing to do a unit on whales would be poorly advised to concentrate on only the biology of whales. Rather, s/he should draw upon the wealth of information and actitivities associated with whales in art, music, literature, science, history, crafts, mathematics, and so on. How to accomplish this is the basis of this article.

The next term in need of defining is "infusion."

"The last thing on earth I need is another new subject to teach!" This common refrain is a valid one, verbalized from Maine to Hawaii by elementary teachers pressured to improve their students' reading and math skills by one grade each year.

While we would be quick to point out the importance of marine education, it should not detract from the 3 R's. Marine subjects should be taught with full emphasis toward accomplishing basic and advanced skills. However, the means by which these skills can be accomplished are varied. What we are suggesting here is that marine themes be used as frequently as possible as the vehicle for accomplishing these skills. For example, reading skills can be taught using marine-related themes, and craft activities to teach psychomotor skills can utilize seaside materials. Literally hundreds of marine activities actually do exist in these and other disciplines. This is what infusion is: teaching your regular courses with the objectives you wish, but integrating them with a marine education theme. Put another way, infusion allows you to achieve your "marinating" objectives while covering your coursework.

To Begin

Let's start with a strong point of most elementary teachers in the United States: reading and literature. Coincidentally, these are the areas best suited for marine-education infusion and the areas with the greatest variety of resource material available.

The first step to designing a meaningful marine education experience for your elementary school youngsters is to select a book with a marine setting, preferably one that is well known and/or well reviewed. This could be a fiction book, such as the ever popular books by Robert McCloskey, or a non-fiction book relating the story of an animal, plant, or natural area such as ***Grandma's Beach Surprise*** by Ilka List.

Read the book carefully. Is it suitable for the grade you are teaching? Is it interesting? Does it reinforce positive humanizing ideals and marine awareness? Ask yourself these questions to be sure you have the book that will best meet the needs of both you and the class.

The step that naturally follows is to select a marine-related theme to tie in with the book. These themes can be obvious or not so obvious ones.

For example, ***One Morning in Maine***, a delightful book for young readers by Robert McCloskey, takes us through a day in the life of Sally, a young girl who lives on a Maine island. A teacher doing a social studies unit on different areas in the United States might wish to use this as representative of the coastal northern New England region. A teacher might also use the book in a lesson on the differences between islands and peninsulas.

However, other less obvious uses are possible. Since the book describes Sally's father digging clams and subsequently preparing them in a clam chowder, the book is a natural tie-in for a unit on nutrition, culminating in a chowder-making activity! Another unit can be designed around a dental health theme, as Sally's loss of a tooth is a central issue in the book. In fact, just such a unit has been designed and successfully tested in New England.

Of course, the above examples are just a few of hundreds. Marine themes can be infused into the basic skill areas of reading, writing and mathematics as readily as they can in supplemental curriculum areas.

The Next Ingredient

After choosing both a book and a marine-related theme, write down the title of your marine education experience. Below that, list the book to be used and the marine theme you selected.

Next, list the outcomes or learning objectives you hope your students will gain from the unit. It is best to keep these simple, direct, concisely stated, and measurable. As you embellish your unit, you can go back and add additional ones.

Once these are done, you must decide on appropriate learning activities which relate to and help to reinforce the learning objectives you wrote. Teachers tell us that this is often easier to do if your learning activities are divided into traditional ones (i.e., reading, writing, spelling and listening) and activity-based ones (i.e., observing, drawing, constructing).

With this list completed, go back over it and flesh it out a bit. Elaborate on each activity with a few key words. Can any of the traditional ones be accomplished with more student involvement? Can the spelling list be used as a game? Is the sentence-structure activity better carried out as a small group activity? This is also the point at which audio-visual aids should be added.

Involvement

Your list of activities is fairly complete, but no matter how broad an activity area you have covered, your students will still consider *you* the "expert" in the daily classroom environment. So you need to broaden your outlook. Look at your community: school, town, county. Are there people you can invite into class? How about a field trip? There are probably people, both old and young, who have experience in some aspect of your unit, who can explain, demonstrate, lead a field trip; or provide specimens or skills. Perhaps there is an older citizen who still remembers how to make fishing nets, or a merchant marine officer who has been to the country you are studying. These people are what make a unit come alive. Whom can you contact? The list is endless and varies from locale to locale. Here is a sample of people who are good bets:

County Extension Agents
Community Businesspersons

Marine Advisory Service Agents
Medical Personnel
Commercial Fishers
Marine Historians
Senior Citizens
Authors
Craftspeople
Photographers
Folksingers
Poets
Folklorists
Coast Guard Personnel
Divers

It is important to obtain an interesting and interested resource person. You should call and arrange a time to meet with him/her first. Explain what you want. Ask the resource person for his/her ideas. It is better to short-circuit an impending classroom disaster at this stage, rather than thirty minutes into the fiasco. Remember that a resource person is best used to *demonstrate* his/her skills. Few resource persons are comfortable in the role of lecturer. But poets can help students write poetry or a lobsterer can show the class how to build a trap and rig it.

Integration

Nowhere is the expression, "No man is an island" more appropriate than in curriculum development. In today's world, no subject can or should be studied in isolation. This is particularly true of marine education with its economic, scientific, political, and social implications.

What is needed in your unit, then, is integration. Look over your freshly expanded unit. Are there opportunities to integrate other subject areas into it? Instead of a spelling list, can you integrate a poetry-writing or language arts experience? How about asking a poet in for help?

If your unit involves reading a book on a child's discoveries about ocean life, integrate a science experience along the same lines. A book that involves a ship in some way is a natural lead to historical material on ships. Most elementary school teachers do not need to be told the importance of integrating art and music experiences into any learning unit. In this regard, there are literally thousands of marine-related songs and skits for elementary school children. In the art area, simple materials can be used to create fairly complex constructions by students as young as kindergartners.

Values

"Teaching is valuing," according to an old maxim. Whether a teacher agrees with this generalization or not, giving students the chance to clarify their values toward the aquasphere is critical. This is what allows a good marine education unit to become a great learning experience.

Near the end of the unit, allow your students time to discuss the learning experience as it pertains to their new knowledge of the world of water. Propose some "what if..." questions for discussion or debate. We have seen first graders handle these questions, sitting in a circle, with a seriousness and intensity that is amazing. Of course, the discussion itself is a language arts activity and a meaningful one at that. However, more importantly, it gives both students and you the chance to think of the water world in a personal, internal way. It allows students a chance to compare with their peers their values and feelings about the water world and to realize their future roles as guardians of the well-being of our water planet.

Evaluation

With the unit now completed, it is essential that you prepare a method for evaluation. This need not be a formal, objective test evaluation. Often, particularly for the lower elementary grade students, a simple project or series of verbal responses is adequate.

If teacher aides or volunteers are used, allow them the opportunity to evaluate the unit. Without a method of evaluation, it is difficult to assess the success of even the best planned units of instruction. Then, sit down immediately afterward and plan revisions for the next time you will teach the unit.

A Final Word

One last word of advice. Teachers often work in a vacuum, needlessly feeling alone with their needs as they construct a curriculum. Marine education is an excellent way for teachers to work in groups on these problems. Generate an idea, share it with your colleagues, and work together to design an effective learning experience. Marinating your classrooms can be as much fun for you as it is for your students!

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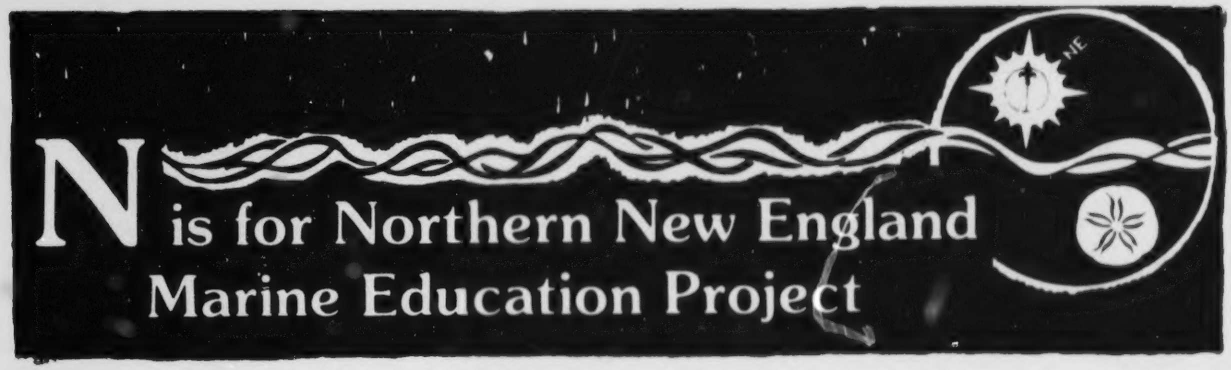
Project COAST Annotated Bibliography of Books, 1979. University of Delaware, Sea Grant College Program, College of Education.

Project COAST Annotated Bibliography of Films, 1979. University of Delaware, Sea Grant College Program, College of Education.



N is for Northern New England Marine Education Project

Since its inception in August of 1977, the Northern New England Marine Education Project (NNEMEP) of the University of Maine at Orono (UMO) has enjoyed grant support from National Sea Grant as seed money to develop, trial test and revise a series of teachers' resource guides for general marine education. NNEMEP was begun in response to a general concern being felt at the national level, but especially critical in coastal states where marine resource development and economic growth have long lain dormant.

Presently, the major purpose of the Northern New England Marine Education Project is to produce education materials with a marine foci for use by classroom teachers of Maine and New Hampshire. In 1981 and again in 1982, the National Science Foundation provided funds for editing and disseminating more of these infusion units especially for middle and junior high school use.

The marine education units which were developed in this program are intended to be innovative and multi-disciplinary. The units are innovative in that they are designed to be used by classroom teachers as they are teaching within their standard disciplines and grade level objectives. That is, these units do not constitute a separate course of instruction, but are intended to infuse marine topics into the study of standard school subjects. The following are brief descriptions of the updated units. These were specifically designed for grades 5-9 but can be used in a wide variety of grades and settings.

1. ***Have You Been to the Shore Before?*** is a comprehensive study guide to the Maine and New Hampshire coastline. The teacher background materials describe the rocky shore, the sandy shore, the muddy shore and the shingle beach and explains where marine plants and animals may be found. Numerous study suggestions and illustrations are provided for the most common marine plants and animals. Directions for establishing a marine aquarium are provided. Activity procedures deal with science, language arts, mathematics and art areas of study. Museums, field study sites and a list of resource persons complete the unit.
2. ***What is Our Maritime Heritage?*** was designed to familiarize teachers and students with our heritage of ships and their importance to us today. Sections on maritime history, boat construction, the basics of sailing and Northern New England ships and shipping are found in the teacher background guide. Classroom activities are designed to introduce students to the parts of a vessel, fan sailing, chanties, making scrimshaw, and building a model walking beam engine. Teacher Resource and Places to Visit sections are intended to aid teachers interested in expanding the knowledge of our maritime heritage.
3. ***How do People Use Lighthouses and Navigational Charts?*** is an NNEMEP unit intended to help students learn vicariously about the shape of the sea, and its coasts and contours by studying navigational charts, the maps of the sea, navigational aids, the road signs of the sea, lighthouses and navigation. Teacher resources, annotated bibliography, and places to visit sections complement an extensive classroom activity section which ranges from lighthouse characteristics and chart symbols to a log writing exercise and "The Challenge of Head Harbor Passage" game. A pocket section contains many useful charts, tables, and lighthouse sketches that instructors may easily copy for classroom use.
4. ***What Adventures Can You Have in Wetlands, Lakes, Ponds and Puddles?*** has a special purpose to make available teacher-tested ideas and activities for classroom and field trip use to wet environments. The teacher-background information provides a guide to puddles, wetlands, streams, lakes and ponds. Activities in the classroom cover a marsh food web, making good use of the film medium, and creating an aesthetic classroom environment. Stream exploration and a puddle study around the school site are two of the field activities described in this guide. Teacher resources, an annotated bibliography and pocket sections are also included in this unit, plus an annotated filmography section.

5. ***Is Our Food Future in the Sea?*** is a unit on aquaculture and sea farming that seeks to introduce teachers and students to the biology, economics, and gastronomics of sea farming, especially of shellfish. Among the organisms discussed in the teacher background section are the blue mussel, the oyster, finfish farming, the lobster and the marine algae. Classroom activities include eating mussels, a crustacean study, an aquaculture equipment, mussel dissection, water and nutrient passage in mussels and "the World Oyster Company Game." An elaborate teacher resource section concludes this unit with bibliographies, supply houses, and organizational resources.

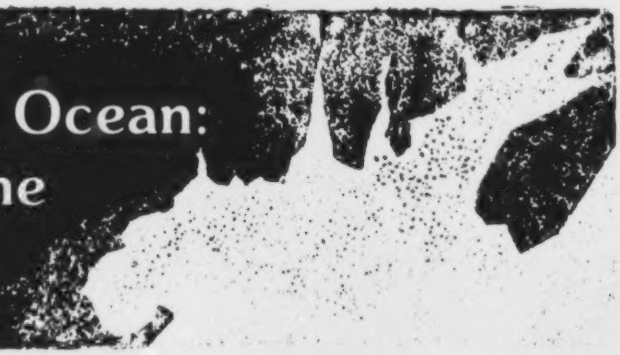
6. ***Do You Know Our Marine Fishes?*** is the unit aimed at making people more aware of the marine fish in the waters off the Northern New England coast. The marine fish and their many relationships to the environment and people are presented in the unit. Activities included are aimed at personalizing the different aspects of marine fish to the student. The teacher background describes the major fish types, biology, commercial, and recreational aspects of marine fish. In the activities section creative writing, literature, home economics, art, biology, and even the "Troller-man" game are among the projects included and designed to encourage student learning. The unit is completed by pocket materials that assist in the activities and awareness of marine fish.

7. ***Do You Know our Marine Algae?*** unit provides teachers and students with an overall look at marine plant life. The background information covers marine algae classification, reproduction, economics, history, culture, and nutrition, while several activities are also provided enabling students to work with marine plants in the classroom and field. The contents of the pocket section provide teachers with many useable diagrams, guides, games, recipes and tables that will greatly ease the teaching process.

8. ***What are the ABC's of Marine Education?*** is a collection of teacher background information and classroom activities illustrating instructional techniques and resources dealing with coastal issues. Among the twenty-six topics discussed are "I is for Islands," "L is for Longitude and Latitude," and "T is for Tides."

Other activities and services performed by NNEMEP include local workshops, consulting and summer courses (usually three weeks in July). An order blank is given in the pocket for the units. If you have need for other information, write to the project director.

O is for Our Own Ocean: The Gulf of Maine

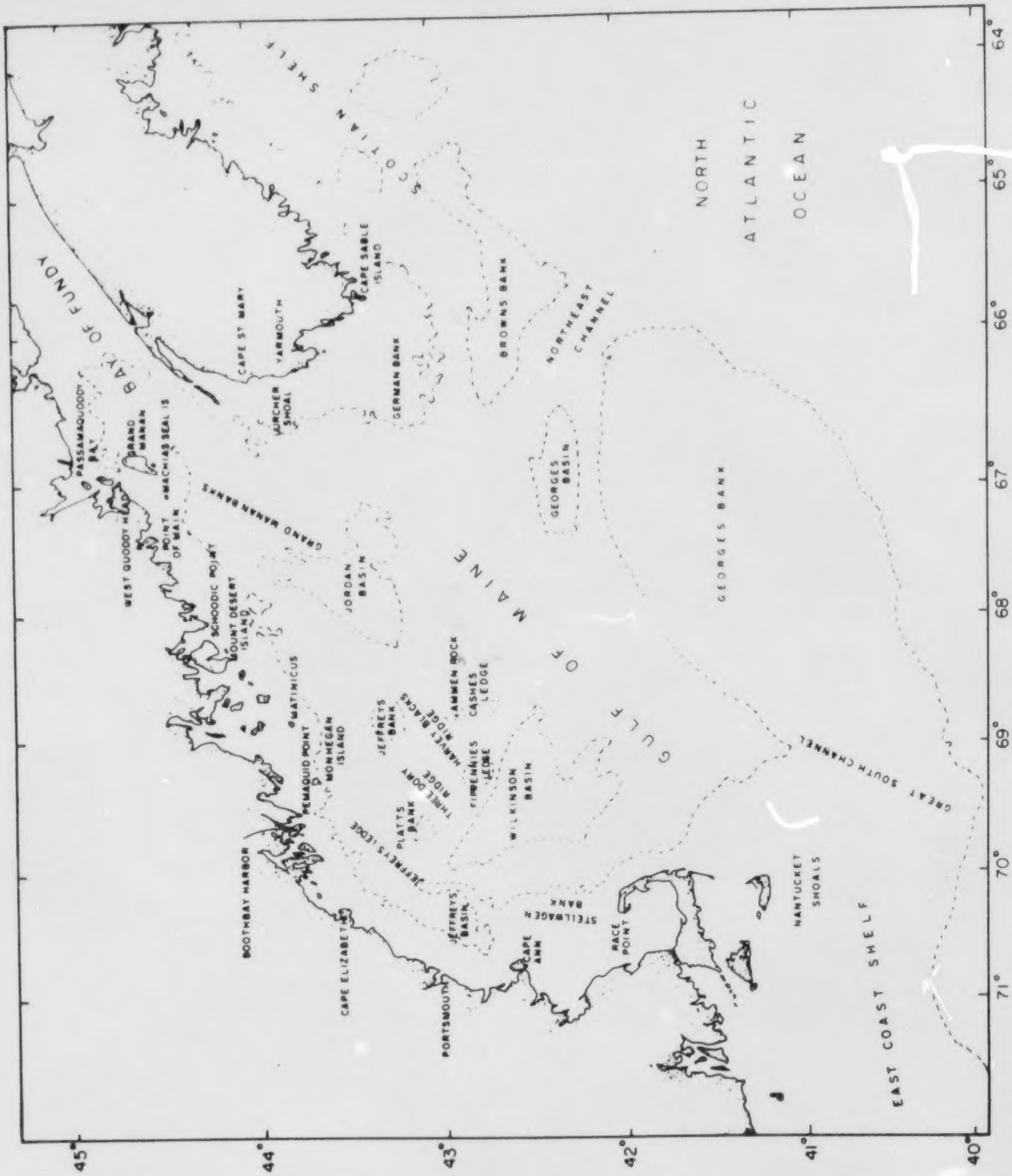


"The visitor to the headlands of middle and northern New England — Race Point, Cape Ann, Cape Elizabeth, Pemaquid Point, Schoodic Point, West Quoddy Head — looks seaward not at the Atlantic Ocean but at the Gulf of Maine. From those ends of land, with nothing in view but the sea, the Atlantic Ocean begins nearly 200 miles beyond the horizon.

The distinction between gulf and ocean is real, and as we learn more about ocean evolution, dynamics, and productivity, the distinction becomes profound and significant. The Gulf of Maine differs from the Atlantic Ocean in its geological history, temperatures, color, salt content, physical processes, and living communities; all these change abruptly as its seaward boundaries are crossed." From the Author's Note

Understanding our own ocean is an important part of developing marine literate students. This inland sea is more populated with valuable marine life than any other large body of water on our entire water planet. For your own background and for use with secondary school students, we strongly recommend Spencer Apollonio's 1979 book, ***The Gulf of Maine***. It is one of those exciting and rare pieces of writing that can change your perception of your environment profoundly.

The book is brief, well-written and covers the critical factors — geography, geological structure, geological history, geological evolution, water flow, mixing, salinity, and currents. The critical demands on the fisheries, oil, and mineral wealth of the Gulf of Maine compel a greater understanding of it by the citizenry of today and tomorrow. The book

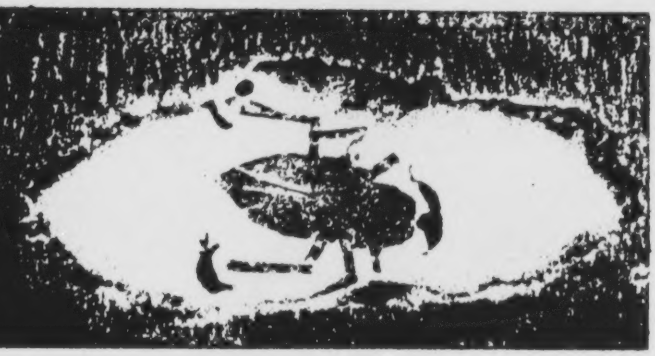

BAY OF FUNDY
SCOTIAN SHELF
NORTH ATLANTIC OCEAN
CAPE SABLE ISLAND
CAPE ST MARY
YARMOUTH
BROWNS BANK
NORTHEAST CHANNEL
GERMAN BANK
LURCHER SHOAL
PASSAMAQUODDY BAY
GRAND MANAN
MACHIAS SEAL IS
GRAND MANAN BANKS
GEORGES BASIN
GEORGES BANK
WEST QUODDY HEAD
POINT OF MAIN
SCHOODIC POINT
MOUNT DESERT ISLAND
JORDAN BASIN
GULF OF MAINE
MATINICUS
AMMEN ROCK
CASHES LEDGE
JEFFREYS BANK
BLACKS RIDGE
HARVEY RIDGE
FIPPENNIES LEDGE
MONHEGAN ISLAND
PEMAQUID POINT
THREE DORY RIDGE
PLATTS BANK
WILKINSON BASIN
GREAT SOUTH CHANNEL
BOOTHBAY HARBOR
JEFFREYS LEDGE
JEFFREYS BASIN
STELLWAGEN BANK
NANTUCKET SHOALS
CAPE ELIZABETH
PORTSMOUTH
CAPE ANN
RACE POINT
EAST COAST SHELF
64°
65°
66°
67°
68°
69°
70°
71°
45°
44°
43°
42°
41°
40°

costs $3.95 and is available from Courier of Maine Books, One Park Drive, Rockland, Maine 04841.

After reading it you will be better equipped to plan activities in the many academic areas which relate to the Gulf of Maine; human history, geography, hydrology, oceanography, and coastal issues. One suggestion follows and many, many others that are possible.

Your students could make a huge map of the Gulf of Maine covering the wall of a classroom (or the whole side of a gym!) showing general water depth, rivers from which fresh water enters, the two channels connecting the Gulf to the ocean, bays, estuaries, underwater basins, and banks. To do this you could utilize navigational charts and illustrations in the book such as the one reproduced here. Younger students might make three-dimensional representations of the Gulf showing basins, shoals, water depth, and canyons using a sand table, modeling clay, or papier-mache.

P is for Puddles



The presence of puddles on the school grounds or nearby lands can open up many new areas of aquatic adventures. A puddle is a shallow, temporary collection of rainwater that may last from a few hours to several weeks. The duration of the puddle depends on the texture of the land where it is formed and the rate of evaporation for the surrounding area. Heavy rains or melting snow usually preceeds the formation of a puddle.

The numbers of classroom and field activities that focus upon puddles and their inhabitors is endless. A class can study the different water cycles developing from the sky to the school's roof, into the drainpipes, gutters and gullies, can follow it into a stream, river, puddle, or lake. A discussion of the problems present in a wet environment can begin around this kind of study and be extended to those particular aquatic problems seen in your community: safe drinking water, clean rivers and streams, the importance of aquatic life in the food chain, or an overall look at your community's water cycle.

Often, hundreds of small plants and animals can be found thriving in puddles. This is an excellent opportunity for students to investigate the different organisms, their metabolism (growth and development) and reproductive methods. One common insect to the Maine/New Hampshire area is the back swimmer (Notonecta, order Hemiptera). Insects of the order Hemiptera (hemiptera means "half wing") are the true bugs that are usually found living in or near the water.

The back swimmer is often abundant in New England's stagnant pools. Its back is dull, yellowish white and its front side is a dark brown or black. As the name suggests this organism swims on its light colored back and, when viewed from above, the only color seen by observers is the dark colored front. This true bug is from 1.0 to 1.5 cm long and has a boat-shaped, streamlined body. The hind pair of legs is used for swimming. Back swimmers will bite if disturbed (a non-poisonous sting) and for this reason water nets should be used to safely capture these organisms.

Being less dense than water, the back swimmers remain at the water's surface unless they propel themselves downward with rowing movements of their widely spread, oar-like hind legs. The back swimmers are excellent flyers. They swarm, occasionally in large numbers, especially in autumn when they seek other bodies of water, where they will overwinter.

In certain species it is the egg rather than the adult that overwinters, and egg deposits may last eight to nine months. The female inserts her egg into water plants with her piercing ovipositor (egg laying tube), or cements them to the plants with viscous fluid. The nymphs, which hatch after three to six weeks, resemble the adults except they lack wings. They mature, after five molts (shedding of skin) in five to six weeks. Back swimmers are predatory insects that capture other aquatic insects swimming in the upper water layers, or other insects that have fallen in, sucking them dry with their strong, sharp proboscis (snout).

Activity
Back swimmers and pickle jar puddles

Objective
To create an indoor wet environment for observation and study.

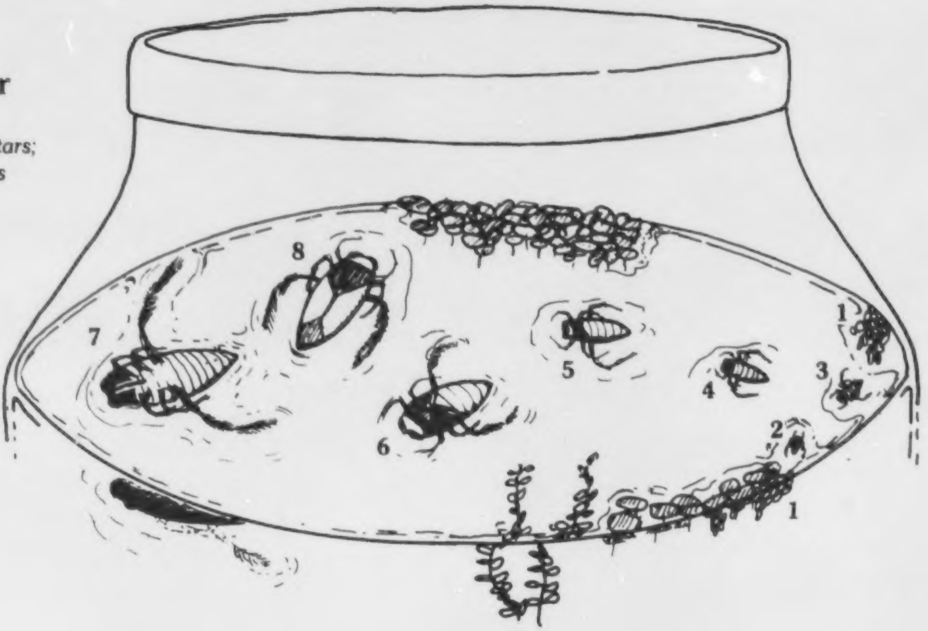
Materials:

- Several large glass jars with lids
- A small amount of sand for each jar
- Living plants and back swimmers collected from nearby ponds or puddles.

Procedure:
Obtain large glass containers for each small group of students; three students to a jar is a workable number. The lunch program in your school may have extra two or three gallon jars with lids.

Each jar will become its own closed system. Plan for one period of creating the system with ingredients brought from home by students or gathered by the class on a field trip. Fill the jars with pond water leaving several centimeters of air at the top of the jar. If tap water is used, allow it to chlorinate for forty-eight hours before live organisms are introduced.

Place a small amount of sand in the bottom of each



Lifecycle of a Backswimmer

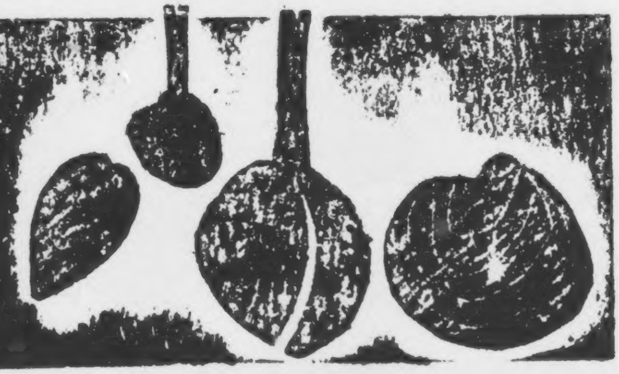
1. Egg masses; 2. through 6. ventral views of nymphal instars; 7. ventral and, 8. dorsal views of adult backswimmer.

pickle jar and allow it to settle. Add rooted aquatic plants such as Elodea and floating plants such as duckweed. Include one back swimmer for each jar and put the lid on tightly. Place the jars in an area where sunlight is available for several hours a day. Back swimmers eat other small, soft-bodied insects common to the area. They will also survive on the pre-packaged aquatic animal food available in pet stores (i.e., turtle food).

Students can now observe this interesting and quite active insect in its natural environment. You may wish to have students keep a journal of their thoughts and observation over a long period of time. You may ask several thought-provoking questions that students can answer verbally, in their journals, or as a take home assignment. Sample questions might refer to a closed vs. open system, those food chains present in each pickle jar, the ecological niches of the organisms, the energy flow through the pickle jar puddle, and the life history of the back swimmer.

For additional information on puddles see the Northern New England Marine Education Project (NNEMEP) unit entitled ***What Adventures Can You Have in Wetlands, Lakes, Ponds and Puddles?***

Q is for Quahog: The Hard Clam



Quahog Dissection

The dissection of shellfish requires care because clams have few colored organs. There are, however, many things that can be readily seen and the observations made during dissection can serve as the basis for discussion.

The dissection deals specifically with the Quahog, *Mercenaria mercenaria* or the old name *Venus mercenaria*, but will apply equally well to many of the other bivalves (oysters, *Ostrae edulis, Crassiosteria virginica;* soft shell clams, *Mya arinaeres;* mussels, *Mytilus edulis;* and bay scallops, *Aquipecten*).

The clam should be opened and dissected in salt water to reduce the damage to the gill and mantle structures, and the initial cutting of the adductor muscles requires a sharp knife. For these reasons, it is suggested that the teacher provide students with precut specimens or allow two to three animals for the student to "practice on" prior to starting the dissection. The problem with bivalve dissection is that one opening of an animal will destroy delicate structures.

External Anatomy

There are several things to observe about the outside of the clam. Figures for this dissection are found in the pocket. You will want to refer to them as you read the following background on clam anatomy. The first is the presence of concentric rings on the shells. These are growth rings and there is a direct relationship between the spacings between the rings and the environment, exactly analogous to a tree's ring system. The two valves of the clam are equal in size; however, shell equivalence varies among the bivalves. Scallops and oysters exhibit a marked difference between shells, the right valve being flat and the left convex. Shell shape reflects growth pattern and is characteristic of each species, though pronounced irregularities can occur under disease conditions.

Some clams collected may have small holes in their shells. These holes may go partially or completely through the shell, and are the work of drills which attach themselves to the shells. The drill rasps the shell away until it can feast on the helpless clam within. Drill holes are very regular in shape and are the size of a pencil point.

The umbo is the swelling on the dorsal side of the shell. The swelling forms a beak which points toward the anterior end of the clam. Finally note the lunule which is heartshaped and located ventral and anterior to the beak.

The last external feature to note is the presence of a cartilagenous, rubbery material on the back of the shell. This acts like a hinge and allows the clam to open the two way valves by a pivoting action which will be discussed later. If the organism is healthy, none of the internal organs (Mantle, gills, siphone, or foot) should be protruding from the shell.

Internal Anatomy

If clams have been cooled at 2-3°C for a half hour prior to dissection, adductor muscles will be relaxed and the process of opening shells will be simplified. Insert a flexible knife, and gently slide it across the interior of the upper, left valve. Care should be taken to keep the knife blade from damaging the internal organs, which will be located in the central region of the clam. Three major muscle groups will have to be severed before the shell can be easily lifted to expose the organs: (1) posterior adductor, (2) foot retractor muscles, and (3) anterior adductor muscle. The posterior is largest in size, and the most easily cut. The anterior adductor may be located and cut after the other two muscle groups have been cut, allowing the valves to gape. If there is not a marked relaxation following your cutting motion, you may have to repeat it, always seeking to avoid damaging internal organs, particularly the delicate gills. The hinge ligament is positioned so that the valves are open in a relaxed mode. The shells or valves are held closed by the constriction of the adductor muscles.

You will immediately be confronted by the unfortunate fact that almost everything inside a clam is the same color. Also, many organs are similarly shaped and tend to overlay each other. Before examining the organs, you should examine the shell interior. When all muscles have been severed, lift the valve up and locate the pallial line which marks the place where the mantle attaches. The inner layer of the shell is completely different in texture and color from the exterior portion of the shell. This is because the shell is not one material but is composed of layers of different materials. If it were possible to observe the cross-section of the shell under a microscope, three distinct layers would become apparent: the inner or peristracum layer, composed of conchiolin (mother of pearl), and two outer crystalline layers composed of calcium carbonate and conchiolin.

In certain bivalves, the mantle is fused ventrally and attached to the shell, as in the Quahog. In some bivalves the mantle is not fused ventrally and not attached to the shell. Because of this distinction, it is possible to identify dried shells of different bivalves by the presence or absence of the pallial line. It should also be noted that in certain bivalves, this pallial line is deformed into a pallial sinus by the presence of the exhalent siphon as in the Quahog. A dried shell can tell you a lot about the animal that lived in that shell. It can be used as a rough identification aid to separate certain members of the class Bivalva such as mussels from clams. The shape of the pallial sinus gives you an idea of the importance of the exhalent siphon to the animal. Burrowing animals depend upon this organ more than non-burrowing animals. The number and location of the adductor muscles can also be used as an identification aid. It is suggested that to fully demonstrate the differences described above, the teacher should display dried scallop, mussel, and clam shells.

The gill is actually composed of two W-shaped ctenidium, fused along the dorsal surface. After examining the left gill in place, you may remove it by lifting and cutting carefully along its entire length. You will find that it is attached to the main mass of organs along a rather straight line from the mouth area to the posterior adductor muscle. When the gill is removed, the digestive organs should be easily exposed, although you should not plan on exposing the entire digestive tract, as the organs are positioned in layers.

The digestive system of bivalves consists of an esophagus, stomach, digestive diverticulum, midgut or intestine, and hindgut or rectum. Water is drawn over the ctenidia, and the food particles are sorted out and covered with a mucous material.

This food package is carried towards the palp and the mouth by tiny hairlike projections from the cell. These projections are called cilia and their beating creates a current directed towards the mouth. On reaching the palp, the food is sorted. The material which is small enough to be accepted passes onward and the larger material is passed outward towards the periphery of the mantle. The mucous-bound food enters the mouth from the oral grooves of the palp and moves to the stomach via a short esophagus. Once the food reaches the stomach and intestine, it is subjected to mechanical abrasion by the crystal style and chemical degradation by the enzymes and chemicals in these organs. Food is sorted by ciliary action and conveyed to the digestive diverticulum and eventually is excreted into the cavity of the shell. Here the feces (the matter which has passed through the digestive tract) and the pseudo-feces (the material which was rejected at the labial palps) are both discarded through the excurrent siphon to the outside.

The foot is the organ of locomotion. In animals such as the hard clam, the foot is used to burrow. Burrowing is accomplished by extending the foot through the mud and then causing the terminal (end) portion of this organ to swell, acting as an anchor. When the foot is secured, the retractor muscles which normally retract the foot are contracted, and since the foot is secured, the body moves towards the foot rather than vice versa. The hard shelled clam has developed a wedge-shaped foot to facilitate this burrowing action. This wedge-shaped foot is so pronounced that the animal derives the name of its order from it: wedged or hatched foot *Pelecypoda*.

The gonads usually lie in the foot below the body mass, and depending upon the species and time of year, their size can be highly variable. The Quahog can change their sex in response to the need to balance the number of males and females within the population. This sex change can occur either as a single event or several times during the lifetime of the animal. Fertilization occurs externally, although the animal may hold the fertilized eggs within the shell in response to adverse environmental conditions.

The hardshell clam has a "open" circulatory system whereby blood is pumped through arteries and veins with large spaces (sinuses) between the two. The heart has a muscular ventricle and two auricles. The heart is anterior to the posterior adductor muscle. Cut into the pericardicum to observe the heart.

After you try the dissection yourself, duplicate and distribute the clam dissection figures from the pocket to your class. You may want to use three days for this dissection. Day one could be used for introduction and external anatomy along with comparison with other bivalves either living or dried shells. Day two could be opening practice along with an overview of internal anatomy with dissection groups working along with teacher. Day three could be complete dissection of a whole mussel and/or an additional organism such as an oyster or follow-up discussion.

Clams may be collected or purchased from the supermarket or fish market. Clams may be kept a week or so in the refrigerator without water or returned to the refrigerator after partial dissection to wait for the next class.

A Note on Safe Collecting Of Marine Organisms:

If you plan to collect specimens, it is always a good idea to check first by telephone with the Marine Patrol Officer of the Department of Marine Resources who is responsible for the town where your field trip will take place. There may be a local shellfish ordinance with which you must comply, a ban on some species due to Red Tide, or the area may be closed due to pollution of other types.

If the growth conditions of light, temperature, nutrient level, and salinity are in certain proportions, there may be a bloom of Red Tide. This occurs when the dominant phytoplankton species which multiplies rapidly under these ideal conditions is *Gonyaulax tamarensis*. These phytoplankton produce chemical substances within their cells that are toxic to animals. Filter feeders such as clams, mussels, and oysters concentrate the toxin in their systems. Whelks, snails, and others that eat the filter feeders also become toxic. When a person eats these creatures, he or she may suffer from a paralytic shellfish poisoning (PSP) which can result in illness and death. Fish, crabs, and lobsters contact this phytoplankton only indirectly, do not concentrate the toxin, and are safe to eat.

It is illegal to collect lobsters in any stage of development — larval through adult. Other marine organisms may be collected without a license when collected in small quantities. It is enormously important if you feel it is necessary to collect, that you stress conservation and make plans for effective, humane transportation of the living things back to school.

The quahog is also called the hard clam or cherrystone. When small they are often eaten raw on the half shell. Hard clams make great chowder.

Quahog Chowder

3 liters quahogs (hard clams)
1/4 cup salt pork, diced
1/4 cup chopped onion
1 cup clam liquor and water
1 cup potatoes, diced
1/2 teaspoon salt
dash pepper
2 cups milk

Steam clams open (5 min.) and save liquor. Chop. Fry salt pork until golden. Add onion and cook until tender, transparent. Add liquor, potatoes, seasonings and clams. Cook about 15 minutes or until potatoes are tender. Add milk. Heat. Serve with large pilot crackers.

R is for Reading Marine Literature

"...There is a majority of children who have not experienced the oceans or lakes firsthand. Most have not even been to the beach, and we recognize that a trip to the beach is only a first step in understanding the vastness of the waters that surround us.

Therefore, to educate for marine awareness, we must look to vicarious experiences for children...in the case of children who have not experienced the oceans, literature becomes the very best way for them to become aware of the potential of the sea to their own future."

Norma Bagnall

Reading about the sea is one of the most fun and rewarding activities we can offer our students. Many books of high literary quality and artistry are available. We describe only a few of our favorites below:

Age Group: Elementary Grades
Day, Michael E. and Whitmore, Carol. ***Berry Ripe Moon.*** Peaks Island, Maine: Tide Grass Press, 1977.
A sensitive and accurate portrayal of the Native Americans' relationship to the sea before contact with Europeans. An educational guide is available also. 56 pages. Line drawing illustrations. (Grades 3-6).

Holling, Clancy H. ***Pagoo***. Boston: Houghton Mifflin Company, 1957.
The now classic story of a hermit crab's life cycle. A fun and scientifically accurate look at life in the tide pool. The full page color and marginal black and white illustrations are superb. A film, ***Story of A Book***, which follows the making of ***Pagoo*** is available from Pied Piper Productions. 87 pages. (Grades 3-9).

Jones, Dorothy Holder and Sargeant, Ruth Sexton. ***Abbie Burgess, Lighthouse Heroine***. Camden, Maine: Downeast. Reprint 1969.
Abbie became a legend through her resourcefulness and bravery. This story recounts her remarkable young womanhood on Matinicus Rock in the mid-nineteenth century. 190 pages. (Grades 4-9).

Lionni, Leo. ***Fish is Fish***. New York: Pantheon Books, 1970.
An enchanting story about the way a fish imagines the outside world as described to him by a worldly frog who's seen it. 32 pages. (Grades K-2).

List, Ilka. ***Grandma's Beach Surprise.*** New York: G.P.Putnam's Sons, 1975.
Jesse learns about the beach and its inhabitants as she explores it with her Dad while collecting treasures for Grandma's birthday. 47 pages. Blue-and-rust colored drawings by Ruth Sanderson. (Grades K-3).

McClosky, Robert. ***Burt Dow: Deep Water Man.*** New York: The Viking Press, 1963.
All McCloskey's books capture in a special way Maine coastal life. This one is a tall tale of a fisherman who catches a whale by the tail and bandages it, leading to great adventures. 63 pages. (Grades 1-4).

McMillan, Bruce. ***Finest Kind O' Day: Lobstering in Maine***. Philadelphia: J.B. Lippincott Company, 1977.
A young boy makes a rite of passage as he spends his first day as a sternman. Finest kind of story. 48 pages. (Grades 3-5) Photographs.

Tresselt, Alvin. ***The Beaver Pond***. New York: Lothrop, Lee: Shepard Company, 1970.
Throughout the year the lives of beaver and wildlife visitors to the pond are followed. 17 pages. (Grades 1-6) Illustrated by Roger Duvoisin.

Young, Jim. ***When the Whale Came to My Town.*** New York: Alfred A. Knopf, 1974.
A gentle and sensitive story told by a Provincetown boy who watches his town cope with a stranded whale. Remarkable photographs. 36 pages. (Grades 4-5).

Age Group: Grades 7-9
The following is a partial list of marine literature, both fiction and non-fiction appropriate for reading in the upper secondary grades:

Henry Beston	***The Outermost House***
Rachel Carson	***The Sea Around Us***

Rachel Carson	***The Edge of the Sea***
Rachel Carson	***Under the Sea Wind***
Harold Clifford	***Charley York: Maine Coast Fisherman***
Samuel Taylor Coleridge	***The Rime of the Ancient Mariner***
Ernest Hemingway	***The Old Man and the Sea***
Rudyard Kipling	***Captains Courageous***
Jack London	***The Sea Wolf***
Wesley Marx	***The Fragile Ocean***
Herman Melville	***Typee***
Herman Melville	***Moby Dick***
Charles Nordhoff and James Hall	***Mutiny on the Bounty***
Charles Nordhoff and James Hall	***Men Against the Sea***
Charles Nordhoff and James Hall	***Pitcairns Island***
John Steinbeck	***The Pearl***
Robert Louis Stevenson	***Treasure Island***

Captains Courageous is especially appropriate reading for Maine students. The setting is New England waters around the turn of the century, the subjects, a spoiled, wealthy child and the fishermen of a North Atlantic fishing fleet. NNMEP has available for loan a few copies of a preliminary draft unit on teaching this novel in Grades 8, 9, and 10.

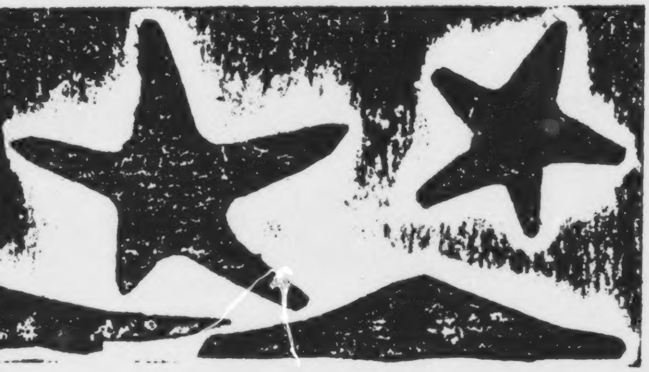
Many projects, traditional and creative can develop from the reading of ***Captains Courageous***. For example, the episode in which Harvey Cheyne falls overboard from a trans-Atlantic liner and is rescued by the fisherman. Manuel, can lead to a discussion or research paper on hypothermia. Interested students can write to the M.I.T. Sea Grant Program (University of Massachusetts, Extension Sea Grant Advisory Program, East Wareham, Massachusetts 02538) for their pamphlet "Survival in Cold Water" or to the Coast Guard (any recruiting station) for their publication AUX 202 (10-76) "Hypothermia and Coldwater Survival." In addition, information on cold water survival suits can be obtained from the Imperial Manufacturing Company, P.O. Box 4119, Bremerton, Washington 98310.

Three good bibliographies are available to help you select high quality print materials:

Sea Sources: Bibliographic and Resource Material of Children's Literature of the Sea. By Norma Bagnall, 1979. Available free of charge from Sea Grant College Program, Texas A&M University, College Station, Texas 77843.

A List of Books on the Marine Environment for Children and for Young People. By Project COAST, 1977. An extensive annotated listing.

S is for Sea Stars in the Classroom



Teacher Background

Starfish or Sea Stars, the preferred common name, abound on most rocky shores and about wharf pilings. Various species live from the tide lines to considerable depths on sand and mud. Boreal Asterias, *A. vulgaris*, is the common species north of Cape Cod.

Sea Stars belong to the phylum Echinodermata. The phyllum name is derived from the Greek, *echinos*, meaning hedgehog and *derma*, meaning skin. Echinoderms are the only animals with complex systems that display conspicuous radial symmetry. Unique features such as a water vascular system, calcareous endoskeleton and pedicellariae probably reflect their ancient origin, the Echinoderms having already been differentiated into Cambrian time.

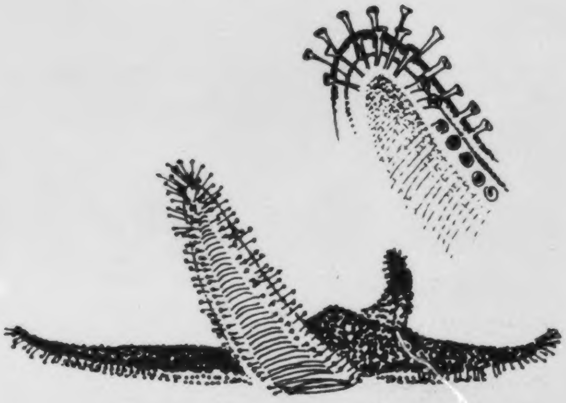
Sea Stars belong to the class *Stelleroidea*, subclass *Asteroidea*, from the Greek words, *aster*, meaning star and *eidos*, meaning appearance. Other Echinoderms include the sea cucumber, sea urchin, sand dollar, brittle stars and sea lillies.

The body of the Sea Star consists of a central disc and five tanering rays or arms. On the upper or aboral surface are many blunt calcareous spines, which are part of the skeleton. Small projections, papulae, between the spines function as gills and for excretion. Around the spines and among the papulae are many minute pincer-like pedicellariae. Each pedicellariae has two jaws moved by muscles that open and snap shut when touched. They keep the body surface free of debris or small organisms and may help capture food. The anus is a minute opening near the center of the aboral surface. The madreporite is a small plate near the center of the disc. It is perforated and connects with the water vascular system.

In the middle of the lower or oral surface is the mouth. The ambulacral grooves, symmetrically spaced radiating grooves, extend along the oral surface of each arm and from it many slender tube feet protrude in four (or two) rows. On the tip of each arm is a small soft tactile tentacle and a light sensitive eyespot.

The water vascular system operates as a hydraulic system during locomotion. Flagella are located on the madreporite and their beating draws sea water into the pores of the madreporite. The water then passes to the stone canal which has calcified rings in its wall. The stone canal leads to the ring canal, located around the mouth on the oral surface. Five radial canals extend from the ring canal, one in each arm above the ambulacral groove. These canals end in the tip of the arm in a small, external tentacle. Each of the radial canals gives off many lateral canals, one to each of the tube feet. Each tube foot is a closed cylinder with muscular walls, having a sucker at the outer or free end, and a bulb like ampulla at its inner end within the body cavity. When an ampulla contracts, the fluid it contains is forced into the tube foot and extends the foot. The water is prevented by a valve from flowing back into the lateral canal. If the tip touches an object, the muscles may contract and return the fluid to the ampulla so that the foot shortens. Withdrawals of fluid lessens the pressure within the tip and causes it to adhere to the object because of the greater pressure of the sea water or atmosphere outside. The foot thus acts as a suction cup. The tube feet act either independently or in a coordinated manner. They serve to hold the sea star to the substratum, for locomotion and in the capture and handling of food. Sea stars have been observed to walk as much as six inches in a minute. On the soft sand and mud, the suckers are of little use and the tube feet act as little legs.

The functioning of the water vascular system gives the sea star for a unique facility to open the shells of bivalve mollusks. With a bivalve, the starfish lies over the prey, which voluntarily opens its shell at intervals. The sea star can insert part of its stomach in a space only 1 mm. wide between the shells. Also, the sea star can grip the opposite valves with its tube feet and gradually pull them apart (maximum pull 1,300 versus 900 grams resistance by abductor muscles of bivalve). The bivalve can resist a much greater pressure for a short time, but the sea star uses its tube feet in relays and can outlast the bivalve. When the bivalve tires, its abductor muscles start to relax. The sea star then everts its stomach through its mouth opening and inserts it into the bivalve. Enzymes of the sea star reduce the bivalve to broth and it is easily absorbed. When digestion is complete the stomach is retracted. An empty bivalve shell is all that is left behind. Sea stars may feed voraciously but can also go without food for long periods of time. A month old sea star in an aquarium devoured over fifty young clams in six days. On commercial oyster beds, sea stars can cause serious losses. The sea star also relies on its tube feet and pedicellaria to capture food and pass it on into the mouth.



Teacher Guide

Sea stars can be obtained along almost any rocky or especially a shell covered bottom. They may be under rocks, among plants, in crevices, or in tide pools. Also look on wharf pilings slightly below the low water mark. Collect at low tide. For best results, collect small stars, one inch or less in diameter.

Plastic mayonnaise or mustard containers make good transport jars for sea stars. (Check the school cafeteria for jars and clean them with baking soda and hot water and let them air dry.) Metal containers are toxic to marine organisms. One or two organisms per gallon of water is a good rule to follow. Keep cool. If you are traveling far distances, place the gallons in a styrofoam cooler with ice in between the jars and fresh seaweed on top.

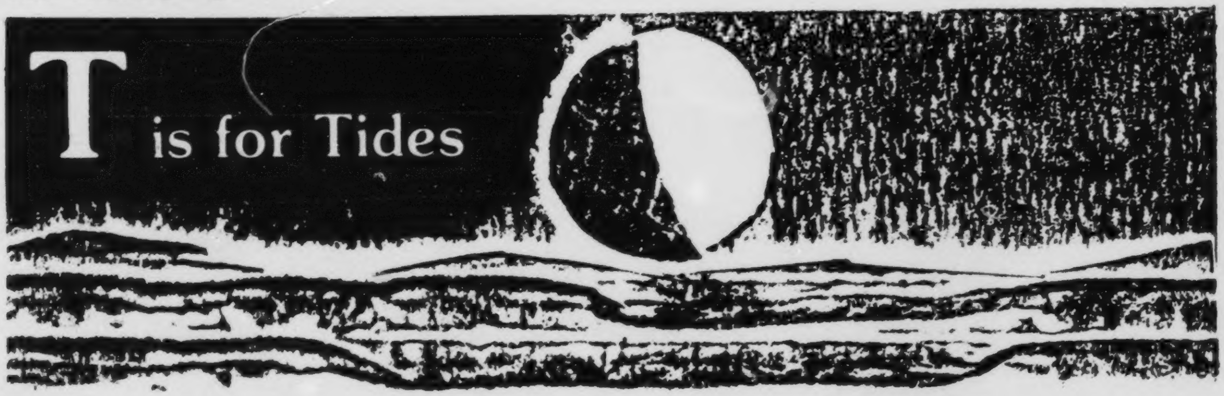
This unit is designed for short term use and does not involve the use of salt water aquaria. Sea stars can be stored in glass gallon containers which have been cleaned with baking soda and water. Fill the containers one half to three quarters full of sea water, with one animal to each gallon container. Keep in the refrigerator at a constant temperature around 2-4°C. Change the water completely every day. Extra sea water should be lightly covered and kept outside in cool shaded area or in the refrigerator until use. Animals may be taken out for one to one and a half hours each day. Feeding instructions are dealt with under A is for aquarium. When the organisms are to be viewed, place in a culture dish with sea water. Use a stereoscope or hand lens for observations.

When you are finished with your specimens, you may wish to preserve them. Follow these directions. For one hour, immerse the sea star in a container to which epsom salts have been added. Then soak in a solution of 70% alcohol or 5% formalin for four to five hours. Remove and allow to dry.

If your school has slides of the cross section of a sea star's arm, they would be interesting to view. You could also make drawings of the cross section. Transparencies on the sea star are available or could be made by the teacher along with any other necessary diagrams.

Most high school biology texts contain a chapter on the Echinoderms. Two films are available from the University of Maine film rental library. They are: ***Echinoderms; Sea Stars and Their Relatives*** and ***The Life Story of the Sea Star***. Also the Peterson field guide series, ***Field Guide to the Atlantic Seashore***, by Kenneth Gosner, has some excellent material on identification of sea stars.

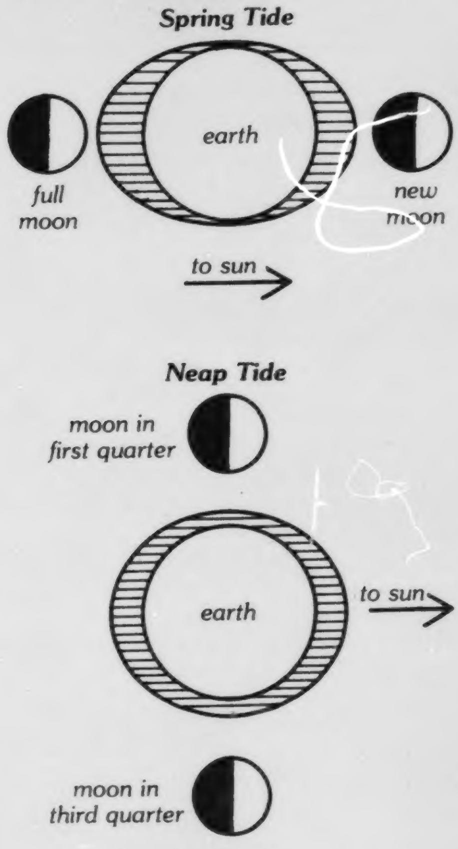
T is for Tides



Practically everyone knows that the world's marine waters rise and fall, to some degree, every day. This information has always been of great importance to sea captains and navigators, especially when guiding ships into and out of harbors and when working vessels in shallow waters around islands and near the shore.

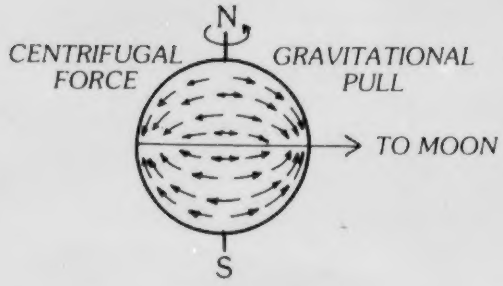
The tides are primarily caused by the gravitational forces of the moon and sun. When the moon and sun are in a straight line with the earth (a new or full moon every two weeks), they pull together and the tides are at their greatest heights. This period is called a spring tide. When the moon, sun and earth form a right angle (during the moon's first and last quarters), the gravitational forces oppose each other and the tidal height is lowered. This period is called a neap tide.

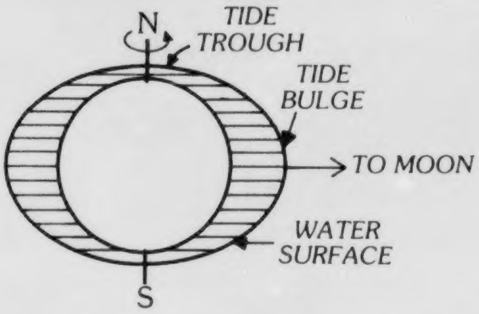
The earth and moon are strongly drawn to each other because of the gravitational forces involved and their proximity. This mutual attraction is balanced by the centrifugal force (a measure of momentum that tends to move the particles of a rotating object away from the center of rotation). The centrifugal force exactly balances the gravitational attraction at the centers of the earth and moon and this is the reason why the tides are high or low simultaneously at opposite ends of the earth. On the side of the earth nearest the moon, the moon's gravitational pull is greater than the centrifugal force, but on the opposite side of the earth the centrifugal force is greater than the moon's attraction. On a hypothetically smooth, water-covered earth, the water would flow toward the moon on one side of the earth and away from the moon on the other side of the earth. Thus, two tidal bulges or crests are formed, separated by two low areas or troughs.



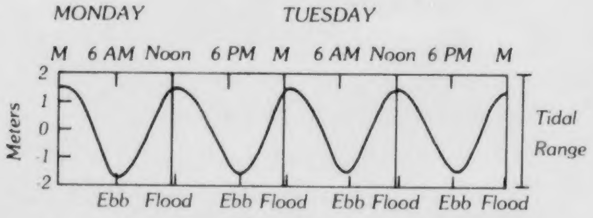
Positions of the sun and moon relative to the earth during the spring and neap tides

Relationship of the tidal-producing forces to the resulting tide bulges and troughs. This diagram

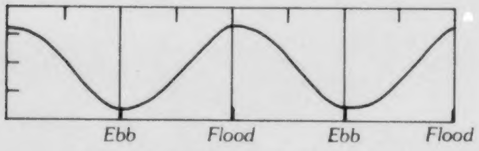




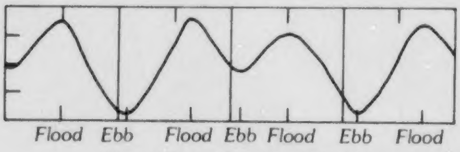
depicts an ocean-covered earth with the moon in line with the earth's equator.



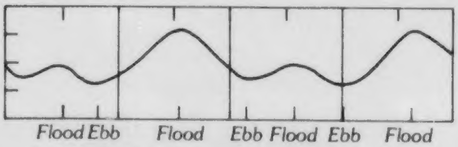
Semidiurnal Tide (Boston, Mass.)



Diurnal Tide (Manila, Philippine Isl.)



Mixed Tide (Seattle, Wash.)



Mixed Tide (Honolulu, Hawaii)

Tides are generally classified into three types:

1. *Semidiurnal* — has two high water and two low water levels each day with little or no difference between consecutive high or low water heights. Semidiurnal tides are common along the eastern coast of the United States.
2. *Diurnal* — only one high and one low water level occur each day. Those tides along the China coast are diurnal.
3. *Mixed Tides* — have both semidiurnal and diurnal characteristics. There are two high water and two low water levels each day, but there is a considerable difference between the heights of successive high water or successive low water levels. These differences are called diurnal (daily) inequalities. The tides along the Pacific coast of the United States are mixed tides.

When conducting a study of the tides, observations of the time and height of rise and fall must be taken each day over a long period. Tidal stations along the coast usually take these observations automatically by the aid of a recording instrument that rises and falls with the tides. After a number of recordings are accumulated from various places around the world, certain characteristics of the tides can be discovered and future predictions can be made. The Northeastern tidal stations that are used by the National Oceanic and Atmospheric Administration (NOAA) are: Argentina, Newfoundland; Halifax and Pictor, Nova Scotia; St. John, New Brunswick; Eastport and Portland, Maine; Boston, Massachusets.

How to Read a Tide Table

Tide tables give the times of high and low tide, plus a number for each high or low tide. This number tells the height of the tide above or below a reference point called the mean low tide. The mean low tide is the average level of low tides. For example, if the tidal level is given as 1.5 meters, the tide level will be 1.5 meters *above* the mean low tide reference point. Negative numbers mean the tide level is *below* the mean low tide.

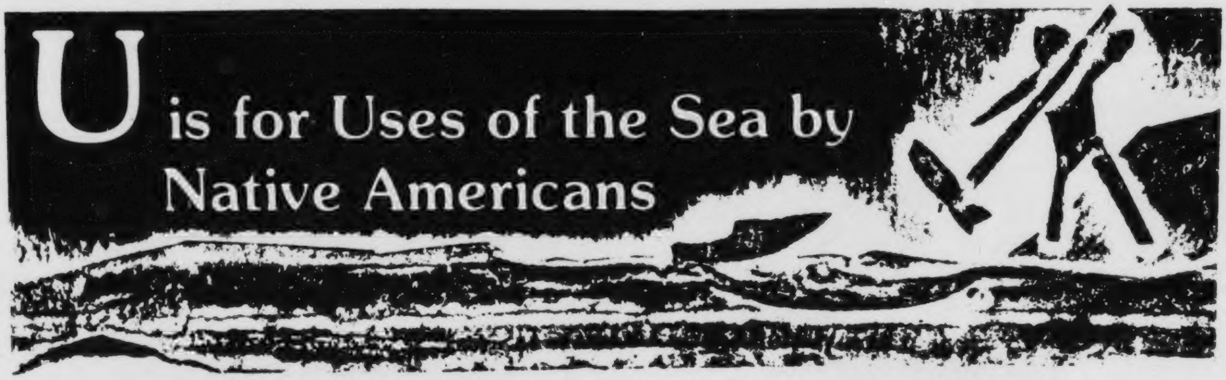
Characteristic Tidal Data

	Water Level (in centimeters)			*Water Level (in centimeters)*	
12:00 a.m.	175	125	*1:00 a.m.*	-20	-60
6:00 a.m.	-175	-5	*6:00 a.m.*	170	-10
12:00 p.m.	175	-125	*9:00 a.m.*	0	-90
6:00 p.m.	-175	5	*1:00 p.m.*	-180	-10
12:00 a.m.	175	175	*7:00 p.m.*	175	125
6:00 a.m.	-175	-10	*1:00 a.m.*	-20	-60
12:00 p.m.	175	-180	*6:00 a.m.*	150	-10
6:00 p.m.	-175	5	*12:00 a.m.*	-150	-130
12:00 a.m.	175	190	*2:00 p.m.*	-180	-90
			8:00 p.m.	170	125
Boston	▲		**Seattle**	▲	
Manila		↑	**Honolulu**		↑

Tidal graphs and corresponding data of the three general types of tides.

Activity
A graphical representation of the rise and fall of the tides for specific days and months can be shown by plotting a curve from tidal data; time in hours and minutes, height in meters.

1. From the data **in the pocket**, plot a tidal curve for Portland, Maine during 6 days in February, 1981. Using the blank graph one provided in the pocket, plot the heights along the vertical axis (the y-axis or ordinate) and the time in hours and days on the horizontal axis (x-axis or abcissa). Connect the points with a straight line.
2. From the same data, plot the tidal curve for Portland, Maine during the entire month of February, 1981. Using two copies each of the blank graph two provided in the pocket, plot the height in meters and the time in days. Also complete the blanks for the stages of the moon and the tidal stages where S stands for spring tide, N stands for neap tide, and A stands for the average tidal stages.



U is for Uses of the Sea by Native Americans

The Native American meaning of the word Abenaki is "place of the Dawn." The tribes which comprised the Abenaki nation were heavily dependent on coastal and aquatic resources for food. The tribes of the Abenaki nation were divided by dialects; first, the Natick dialect included the coastal Pennacooks, and Sokokis. The Abenaki dialect included the Anasagunticooks, the People of the Androscoggin River Valley, the Kennebecs of the Kennebec River Valley. The Etchemen dialect included the Penobscots, Wawinocks, Pemiquids, and the Passamaquoddys.

Natick

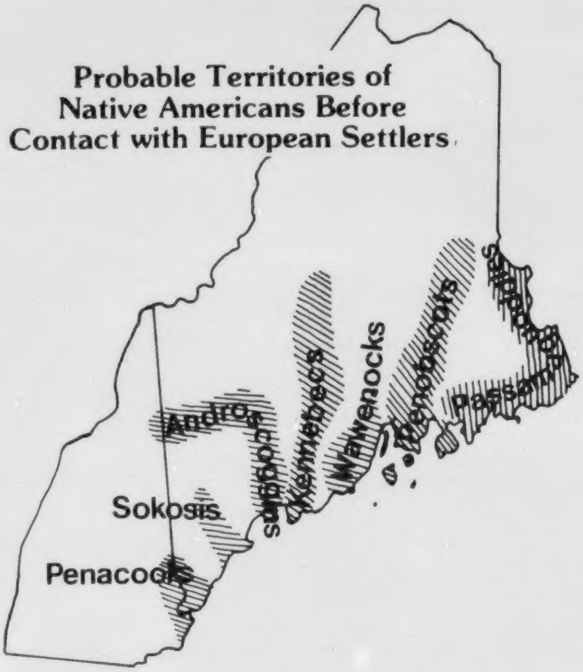
1. *Pennacooks:* These people inhabited the southwest corner of Maine (Kittery, York) and the coast of New Hampshire (Portsmouth, Dover, Great Bay). They probably lived in fixed villages. They grew crops, fished and also hunted.
2. *Sokokis:* These people inhabited the Saco River Valley. They grew crops and hunted.

Abnaki

1. *Anasagunticooks:* These people inhabited the Androscoggin River Valley from Berlin to Brunswick. They lived in fixed villages and depended upon hunting and crops. These Anasagunticooks were the last to make peace with the colonists.
2. *Kennebecs:* These people who were also called *Sagadhocs*, inhabited the Kennebec River Valley from Moosehead Lake to Merry Meeting Bay. They gave much attention to their crops and did some hunting.

Etchemen

1. *Wawenocks "People of the Bay Country":* Their name gives away their locality. These people inhabited the coast from the Kennebec River to the Penobscot River. The Wawenocks did much foraging on the clam flats and grew crops on the coastal islands. Today their huge shell heaps (middens) are all that is left of these people. It is said that Samoset, a member of this tribe who greeted the Pilgrims in English.
2. *Penobscots "People of the Rocky Places":* These people, some of whom presently live in Old Town,



Probable Territories of Native Americans Before Contact with European Settlers

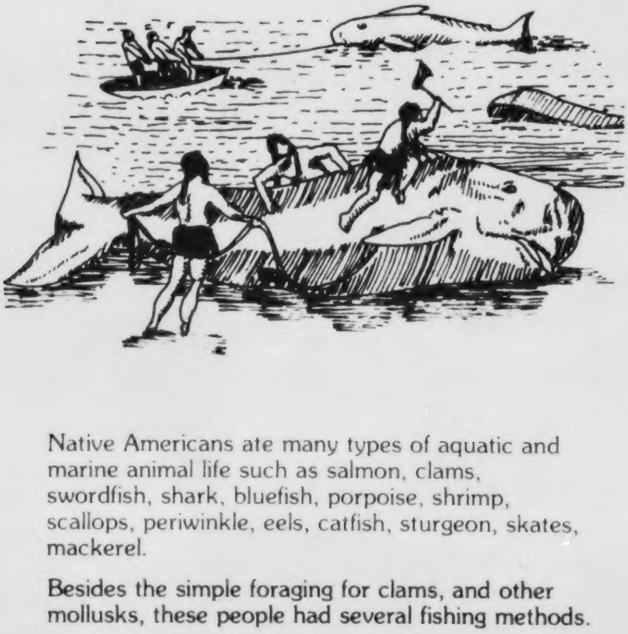
lived in a variety of places. Some lived near Penobscot Bay. Others grew crops on the islands and fished. They also frequented the upper rivers near the falls where they caught salmon and other anadromous fish. They were the most numerous and powerful tribe of the Abenaki Nation. They had influence all the way to Massachusetts. Since the contact period, the Penobscots have shifted to the Abenaki dialect.

3. *Passamaquoddys "The Spearers of Pollock":* These people lived on the coast from the Penobscot River to the St. Croix River. They were bold sailors, hunters of seals, porpoise and whales. They often took their ocean going canoes from Maine across the gulf to Cape Cod. They did raise some corn but depended upon hunting shellfish and fishing. They were probably nomadic, moving from one clam flat to another.

The coastal people at all times depended to a large extent upon the many fish of their lakes, rivers and bays. The George Weymouth Expedition recorder, James Rosen, recorded many kinds of "fish" (water animals) as being utilized (these are given in the original spelling):

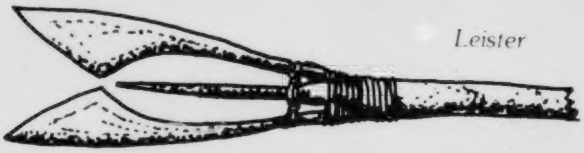
Whales
Cod very great
Herring great
Thorneback
Lobstar great
Muscels great with
  Pearles in them
Cunner fish
Whiting
Tortoises

Seales
Haddocke great
Plaise
Rockefish
Crabs
Cockles
Wilks
Lumps
Soales
Oisters



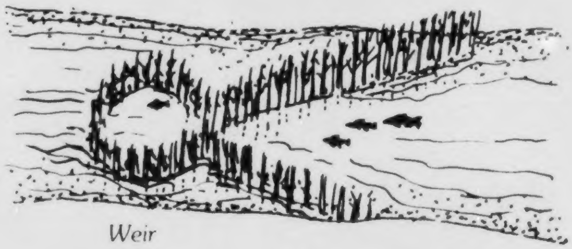
Native Americans ate many types of aquatic and marine animal life such as salmon, clams, swordfish, shark, bluefish, porpoise, shrimp, scallops, periwinkle, eels, catfish, sturgeon, skates, mackerel.

Besides the simple foraging for clams, and other mollusks, these people had several fishing methods.



Leister

1. *Fish spear or leister:* a spruce shaft 2-3 meters long gave the user much range from rocks or canoe. Salmon, pollock and eels were the common victims.
2. *Single tipped spear:* like a leister except no grips; used for spearing turtles, flounder and hibernating eels, lobsters and crabs.
3. *Jigging:* a barbless large size hook made from the crotch of a willow about 7 to 12 centimeters long with its point hardened by charring. The hook was weighted with a stone. This method was used for catching fish in schools such as mackerel and pollock.



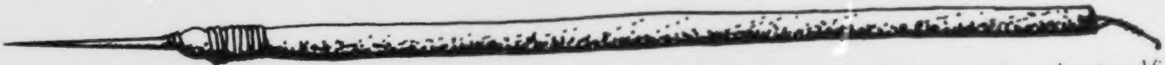
Weir

4. *Hooks:* these hooks were made from bird breast bones (wish bones). One end was rubbed upon a stone to sharpen it. Baited, it was used like modern day hooks. Fish as well as lobsters were caught this way.
5. *Harpoons:* these lances barbed at the end were used to catch salmon, shads, porpoises, and sometimes beaver.
6. *Splint basket traps:* the traps set in streams mostly for eels were constructed from wood splints, probably Basswood. They were about one meter long and one foot wide. They were baited and then weighted down with rocks.
7. *Poisoning fish:* the fish ponds of streams when the water was low were poisoned with plants such as Pokeberries and Indian turnips. The dying fish were then picked up on the surface.

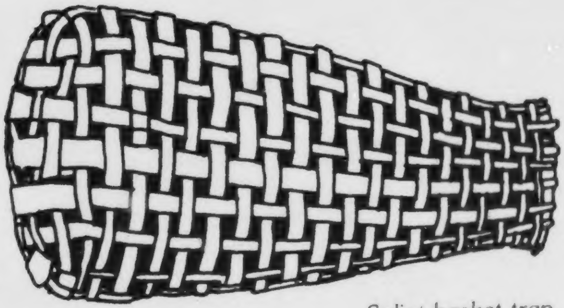
We suggest that your class study coastal utilization in a project or library study format.

Project Ideas

1. Carve fish hooks.
2. Carve fish spear.
3. Make a fish net or fish trap.



Single tipped spear

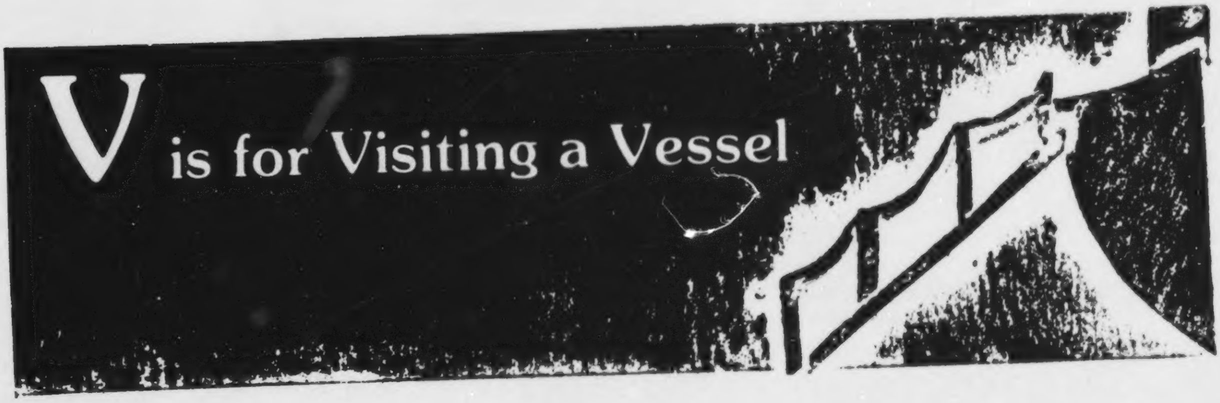


Splint basket trap

Questions/suggestions for investigations

1. Why did the Native Americans go to the coast and at what times of the year might they have done so?
2. What food did they prepare at the coast?
3. What may they have eaten in the winter?
4. Did the precontact Native Americans hunt and fish for sport as we do?
5. What methods did they use to fish?
6. What methods did they use to hunt?
7. What animals did they seek by hunting and fishing in the coastal region?
8. How did the Native Americans keep their fish from spoiling or going bad?

Much scholarship is needed on the precontact Native American's lifestyle. Probably the best source is Eckstrom's ***Handicrafts of the Modern Indians of Maine***. This book was published in 1932 and really deals with the post-contact period.



V is for Visiting a Vessel

Think of the many ways vessels are used in Maine. How many can you list? Were you able to come up with movement of cargo, transportation of passengers, coastal defense, scientific research, or commercial fishing? These are really just a few of the functions served by ships and boats in Maine.

In this section, we will "visit" a vessel and examine use. In addition, we will provide resources to help you learn about the characteristics of various types of ships to determine what makes each unique. By studying vessels, students can develop a greater appreciation of Maine's heritage of ships and will have a better understanding of the roles played by ships in Maine's economy today.

There are many ways you and your class can visit a vessel. The most commonly toured ship is the training vessel ***State of Maine*** moored at Maine Maritime Academy, Castine, Maine. This 533 foot ship is used by the Academy in the training of sea men and women for careers in the merchant marine, the Coast Guard, and other maritime positions, as well as by other educational institutions for marine research. When the vessel is in home port, classes are welcome to visit her. If you are interested in taking your classes on a field trip to the ***State of Maine***, please make advance arrangements through:

Director of Public Relations
Maine Maritime Academy
Castine, Maine 04421
(207) 326-4311

A side view of the ***State of Maine*** is given in the pocket.

State of Maine

Originally, the ***State of Maine*** was built as a luxury passenger-cargo vessel for the American President Lines and was to be named the SS President Hayes. Her construction commenced in 1949 with the laying of the keel at the New York Shipbuilding Company shipyard in Camden, New Jersey. Work was progressing satisfactorily when the Korean War abruptly changed the future life of the ship. The immediate need for troop transports by the United States Navy gave the ship a new owner, and conversion to a troop transport started in September of 1950. She was christened the USNS ***Upshur*** after Major General William Upshur, United States Marine Corps, who was a Congressional Medal of Honor winner for his action in the Haitian Campaign of 1915. After sea trials in December, 1952, the United States Navy accepted her for Military Sea Transportation Service, now known as the Military Sealift Command.

Her twenty years as a troop carrier took the ship to all parts of the globe. In the mid 1950's the ***Upshur*** carried troops and their families in Operation Gyroscope in overseas rotation of military units to NATO areas in Europe. In 1958, during the Lebanon crisis, the USNS ***Upshur*** was one of the primary troop transports taking U.S. military units from Germany to Lebanon. The ***Upshur*** continued carrying troops and families to Europe until 1965, with one interruption — in October of 1962, when she raced to the Guantanamo Naval Base in Cuba to lift some 1700 dependents and return them to the United States just prior to the Cuban missile crisis. In August, 1965, the USNS ***Upshur*** became part of the Military Sealift Command, Pacific and was designated as one of five transports to transport the 1st Air Borne Division to Vietnam. This transport service continued until December, 1967 — when the ***Upshur*** was designated to Far East service in which it completed 65 round trips between Korea and Vietnam carrying ROK units fighting in the conflict.

In April of 1973, the USNS ***Upshur*** was released by the Military Sealift Command to Maine Maritime Academy and the Maritime Administration in Boston, Massachusetts. After a brief drydocking period, the Academy departed on the newly named ***State of Maine*** on a two month training cruise to South America and the Carribbean.

A highlight of the initial cruise for the ship was the transporting of over 200,000 pounds of gift cargo for the Partners of the Americas Program from 10 U.S. states to sister states in Brazil and Columbia. Cargo included a portable basketball floor, X-ray machines, hospital beds, an ambulance and a large supply of school supplies and equipment.

The 1974 training cruise was a first for Maine Maritime Academy, as the training ship ***State of Maine*** visited Leningrad in the Soviet Union in early June. It marked the first time, ever, that a training ship of any kind from the United States, visited a Russian port.

The ***State of Maine*** experienced another first while on training cruise in 1977. She played the part of a Russian fish-factory ship, ***Sovetskaya Litva***, in the Paramount produced TV movie, *The Defection of Simas Kudirka*. It was about the Lithuanian seaman (Kudirka) who made an attempt to seek asylum by jumping to the deck of a U.S. Coast Guard Cutter off Martha's Vineyard in 1970. The film appeared on the CBS network in January 1978.

If you cannot visit a vessel in person, visit one vicariously. There are many plastic and wooden boat models on the market which can be assembled by children. In the process they will learn something about the parts of a vessel. Older students could design and build their own models. The Apprenticeshop Program of the Maine Maritime Museum at Bath can provide information on half-modelling and lofting, two procedures used in boat building, that might be helpful to students in this endeavor.

Students can also obtain information about important seaports in Maine by writing to the Port Authority or Chamber of Commerce of that port. An impressive little booklet about the Port of Portland is available from:

The Port Committee of the Greater Portland
Chamber of Commerce
142 Free Street
Portland, Maine 04101

Another interesting class involvement is to "Adopt-A-Ship." The Propeller Club of the United States sponsors this plan which enables a class (Grades 5-8) to correspond with captains and/or crew members of merchant marine vessels. For more information on the "Adopt-A-Ship" plan write:

The Propeller Club of the United States
1730 M Street, NW Suite 413
Washington, D.C. 20036
(202) 223-1401

Also, ***Woodenboat*** magazine (Brooklin, Maine 04616), the ***National Fisherman*** and ***Small Boat Journal*** (Camden, Maine 04843) and ***Maine Commercial Fisheries*** newspaper (Stonington, Maine 04681) all can provide extensive information on vessels of many types and usually include line drawings and photographs.

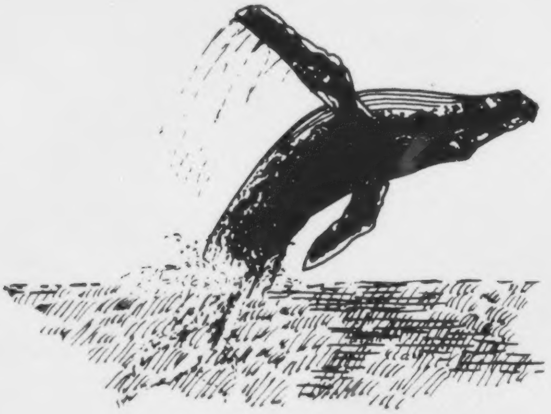
W is for Whale's Tail

Objectives:
To introduce students to a working research technique to improve students' sense of North Atlantic geography.

Materials
The set of tail photos and the map from the pocket.
An overhead projector.
A large wall space and blackboard or paper.
Tacks or tape and string or yarn, scissors.
A world atlas may come in handy.
You may wish to make photocopies of the tail cards and map for each group of 4-5 students.

Background for teachers:

W is for whale's tail because the tail of one species of whale, the 50-foot humpback, is very special to marine scientists. All humpback whales, and only humpback whales as far as we know, carry a pattern of black and white markings on the underside of their tails. It is as unique to each whale as your fingerprint is to you. These humpbacks, named for a small rise of the back just ahead of the dorsal fin and the high arch of the back before deep dives, also lift their tails straight out of the water on deeper dives. Scientists have discovered that it is not difficult to be in the right place at the right time and get a photograph of that pattern. These photographs can be used to compile a sort of 'mug file' which will identify each whale wherever it goes in the world.



As of 1982 over 2000 humpback whales were identified in this way by men and women from all over the western North Atlantic, some of whom have never spoken to each other. More than one hundred people were involved. It has given whale scientists some of the most reliable information on the migration patterns of these whales. It tells us much about the timing and the endpoints of migrations, but little so far about the pathways between.

Game Preparations:

1. The tail photos are arranged in the pocket so that views of the same whales are together in sequence. Review these before cutting the tail views apart so that you can anticipate the kind of problems that students will have with changes in scale and perspective. The trick is to locate specific patterns or markings. Cut these or copies of them into small photo cards of one tail each making certain to include the data below each tail as part of the card. Have one set for each team.
2. Set teams of students up as cartographers of the Northwest Atlantic. Teams of 4-5 are maximum. Each team should have a copy of map enlargements on the board or on poster paper.

Game Strategy: The object is for each student in the role of cetologist (whale scientist) to collaborate with the other researchers from around the Atlantic and learn as much as they can about the migration patterns of humpback whales.

Each team of students will draw their tail photos from a different container. One tail is suggested as a start. They then take their photos and compare them around the team in an attempt to make as many matches as possible. Emphasize that the whale was not sitting still for his portrait and did not always dive with the tail facing the camera at the same angle. The researchers who first attempted this in Bar Harbor, Maine, at the College of the Atlantic, still do the work in the same way, but make their task much simpler by categorizing the hundreds of tails in rough groups of shading patterns. When matching sets is difficult, encourage students to arrange tails from mostly light to mostly dark down the table.

Matched tails are pinned or taped simultaneously on the enlarged map and joined by string and yarn. Alternatively, matched tails may be color coded as dots on the small letter-sized maps. Trios and quartets of matches are possible.

Follow-up Questions (and answers for the teacher)

1. Will any two photos ever give you the exact migration route of a whale?...No, but five or six might begin to give you an idea.
2. What possible way can you think of to tell the exact migration track?...Radio tracking with tiny radios and antennae held on by suction cups is just being worked out. Ships, planes, and satellites all used in this work.
3. Do matched photos always give you the time of the trip between places?...No, but you figure a whale's traveling speed between two and six miles per hour you can figure out which trips were almost direct runs.
4. Did you notice the regular patterns of evenly spaced scratches on any tails? What do you think did that?...As it turns out, the spacing between the scratches corresponds pretty well to the tooth spacing of killer whales. Perhaps they test some whales more often than others to see if they are weak and can be eaten. No one knows for sure.
5. Did you see some very round marks on a few tails and some white clusters near the tips of most? What do you think these are?...A very particular barnacle of the genus group *Cornulus* lodges in the whale's tail skin when it is a tiny wormlike larva and as it grows to its adult round barnacle shape it secretes a material that encourages the whale's skin to grow up through the parts of the barnacle's shell, thereby tricking the whale into hanging on the shell and saving the barnacle that energy.
6. If you number your matched tails in order of the dates on the photos what does this tell you about the direction of travel of the whale? Be careful about making hasty assumptions.
7. Why do you suppose whales migrate?...From what we can tell, the oxygen rich (remember O_2 can concentrate in colder water) northern water which supports much more fish life provides most of the food for the whole year. The humpbacks go south to deliver their calves in warm water and get some fat on them before bringing them north.
8. From what you see of some whales in the same place year after year, do you think whales have "home" places? What would make a place home to a whale?...Apparently, yes and food type, temperature range and family groupings seem to make a home of sorts.

Whale's Tail Card Key

	W1		W2		W3
1a	3a	5a	7a	9a	11a
1b	3b	5b	7b	9b	11b
2a	4a	6a	8a	10a	12a
2b	4b	6b	8b	10b	12b

Whale Resources

Whales on Wheels. Write or phone Marion Kane, College of the Atlantic, Bar Harbor, Maine 04609. 207-288-5015. This is an extraordinary reconstruction of a Minke whale skeleton by children themselves under the expert guidance of COA college staff and students. An excellent follow-up to the slide show.

The Whale Slide Show. Dr. Steve Katona of the College of the Atlantic, has developed a fine slide/tape program, slightly technical but well narrated. 45 minutes or 1½ hours. New edition in progress. Rental cost: $12.00 Allied Whale, College of the Atlantic, Bar Harbor, ME 04609.

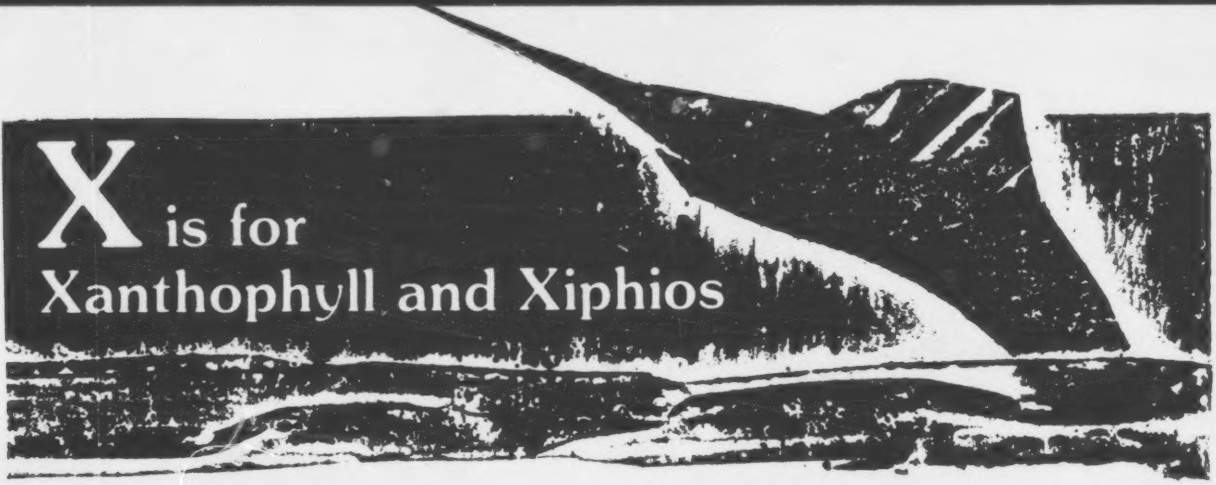
A Field Guide to the Whales and Seals of the Gulf of Maine by Dr. Steve Katona and Dr. David Richardson is the best and most available summary of species, basic biology, and field marks. Clear, accurate illustrations and a very readable text. Cost: $5.50 from Allied Whale, College of the Atlantic, Bar Harbor, ME 04609.

There are numerous whale books in the popular and technical literature, but not many curriculum guides. The most comprehensive single source book available is called ***The Whalebook*** and includes excellent audio visual listings and bibliographies as well as teacher resources. The best of political material also.

The Whalebook by the Center for Action on Endangered Species, Inc., 175 W. Main Street, Ayer, MA and published by the Whale Protection Funds Center for Environmental Education, 2101 L. Street, N.W., Washington, D.C. 20037.

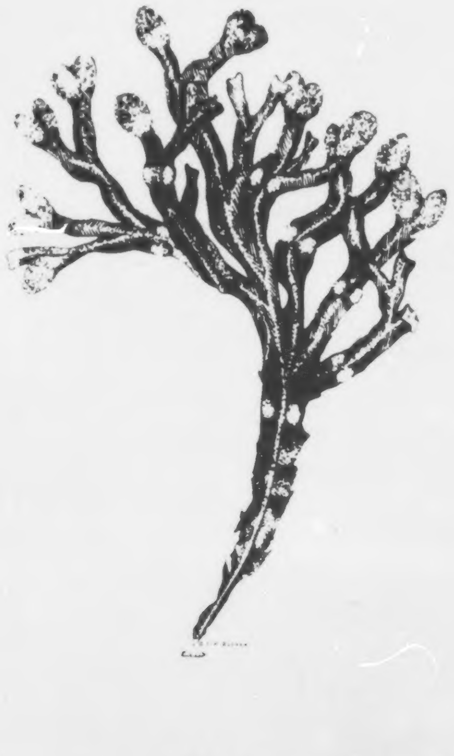
A copy of the latest whale tail catalog printed by the Allied Whale of the College of the Atlantic is available for about ten dollars. It includes a discussion of the problems with this kind of research. The tail photos used in this activity were based on the catalog. Data for location were slightly altered to make results more specific.

X is for Xanthophyll and Xiphios



These sound like horribly scientific terms, but don't let them scare you away! Xanthophyll is the pigment in certain seaweeds that makes them a brown color. Some seaweeds contain mostly *chlorophyll* and are green in color, hence are called the Green Seaweed group. Sea lettuce is a good example. Other seaweeds contain mostly a reddish pigment called *phycoerythrin* and form the Red Seaweed group. Two well-known red seaweeds are Irish Moss and Dulse. Yet another group, the blue green algae contain the pigment *pyncocyanin* and finally we come back to the Brown Seaweed group p containing *xanthophyll*. The common rockweed and bladder wrack which grow so abundantly on the rocks along our coasts are good examples of brown seaweeds.

The Northern New England Marine Education Project has available an instructional unit on seaweeds. Some ideas from the seaweeds unit on food preparation are given below.



Seaweed Cookery:

Irish moss pudding or Blanc Mange:

Blanc Mange I
1/2 cup packed Irish moss
1 liter milk
1/2 cup sugar
pinch of salt
any fruit or flavor
cheesecloth

Wash the algae several times in fresh water. Heat milk and Irish moss in a double boiler. Cook over boiling water for about 30 minutes, not more, stirring occasionally. Strain through cheesecloth and discard the Irish moss. Add sugar and salt to the milk and allow to partially cool. Any fruit or flavoring should be added as it begins to thicken. (Suggested: Blueberries, raspberries, almond flavoring or honey.) Pour into molds and chill in refrigerator for several hours. Can be served with cream.

Blanc Mange II
1/3 cup Irish moss
1 qt. milk
1/4 tsp. salt
1½ tsp. vanilla

Soak moss 15 minutes in cold water to cover, drain and pick over. Add milk. Cook in double boiler 30 minutes. The milk will seem only slightly thickened, but if cooked longer the blanc mange will be too stiff. Add salt, strain, flavor and restrain. Fill individual molds previously dipped in cold water. Chill. Turn molds onto a glass dish and surround with thin slices of banana and place a slice on each mold. Serve with sugar and cream.

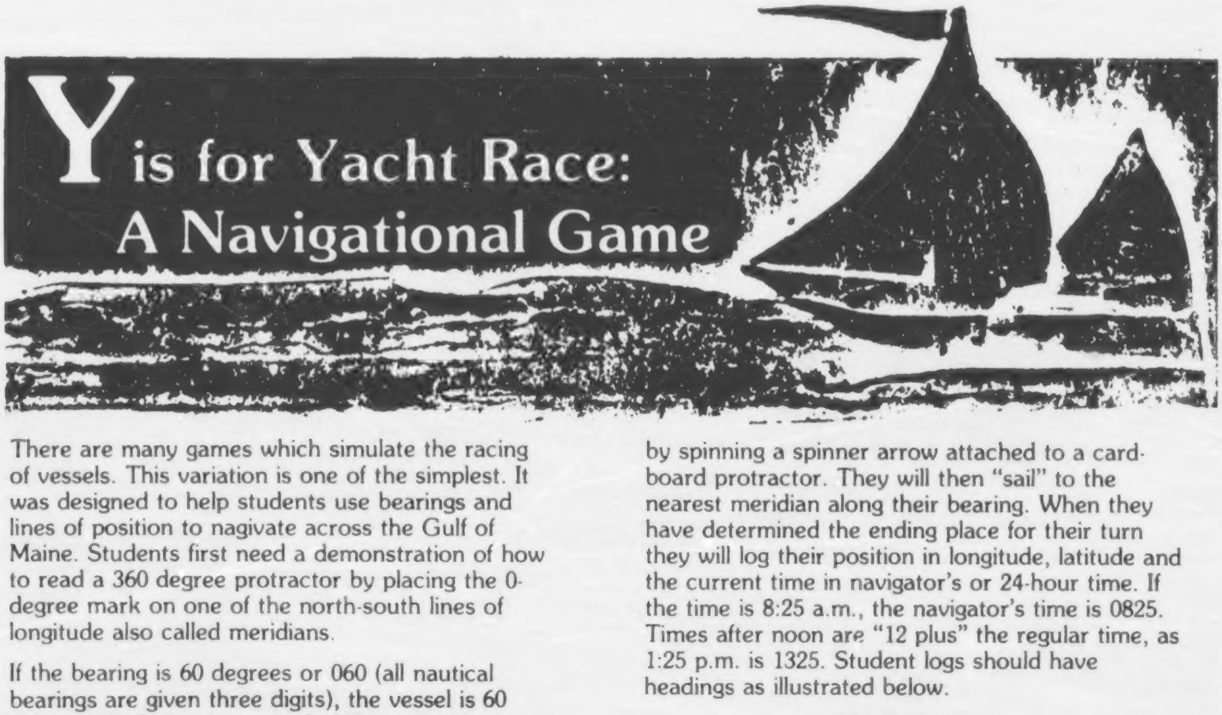
Seaweed Sweet
4 cups of rings cut from fresh kelp
3/4 cup of white vinegar
2½ cups sugar
1 tsp. whole cloves
1 tsp. mixed pickling spice

Remove the outer skin of kelp with vegetable peeler and slice into thin rings or cut into long strips and then into rectangles. Soak the cut kelp in fresh water for 3 days, changing the water several times a day to remove the bitter tasting salts. Place the spices in a cheesecloth bag and place in simmering vinegar and sugar for five minutes. Remove the spices and pour the hot syrup over the sliced kelp. Let stand over night. Next day drain off syrup, heat to boiling and pour over kelp again. Let stand over night. On the following day (sixth) remove syrup and heat to boiling. Place kelp slices into jars, cover with boiling syrup and seal, or store the pickles in a covered crock. For dill seasoned pickles, handle the kelp in the same manner, but substitute your favorite dilling process for the above syrup.

While we are on the subject of color, we could branch off a bit here and say that X is also for *Xiphios* (the Latin word for swordfish) and talk about coloration in fish. Coloring in organisms in the natural world generally serves two purposes: species recognition and protection. Your students should be able to come up with examples of each. Elementary students might like to locate pictures in magazines which illustrate brightly colored tropical fish (an adaptation for species recognition useful in schooling) and fish who are colored to blend in with their surroundings. A simple demonstration that can be done with both elementary and secondary students to teach about protective coloration in fish follows:

If you can get a live flounder, great. If not, make, or have a student make, a realistic model of one. A flounder usually lies on the bottom, sometimes partly buried in the sand or mud. If you have access to a live flounder, try placing it in an aquarium or dish pan of seawater with different kinds of bottom sediment: mud, light colored sand, dark colored sand, multi-colored rocks. Observe the changes in the flounder's coloration on each of these substrates over a period of a couple of hours. Or use your model to show what happens; wrap the "flounder" with paper colored to match the "bottom" of your imaginary ocean. The flounder, then, is somewhat like a chameleon; it changes shade and markings to better blend with its surroundings.

Next, hold the flounder or the model above the heads of your students so that they must look up into the light to see it. A flounder is light-colored below, so that on the occasions when it is swimming nearer the surface, it will blend in better with the lighted surface waters and will be better protected from predators looking up at it from below.



Y is for Yacht Race: A Navigational Game

There are many games which simulate the racing of vessels. This variation is one of the simplest. It was designed to help students use bearings and lines of position to nagivate across the Gulf of Maine. Students first need a demonstration of how to read a 360 degree protractor by placing the 0-degree mark on one of the north-south lines of longitude also called meridians.

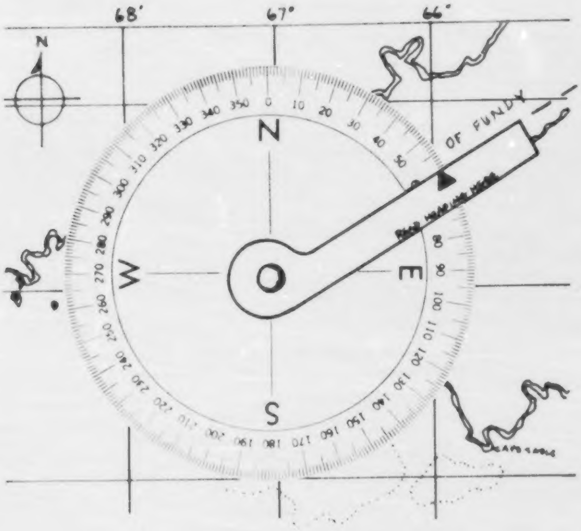
If the bearing is 60 degrees or 060 (all nautical bearings are given three digits), the vessel is 60 degrees clockwise from north. When positions are expressed, they are the points on a line drawn from the center of the protractor through the correct angle position on the edge of the protractor and outward away from the protractor.

In this game players will be given opportunities to determine the bearing of their voyage for each turn by spinning a spinner arrow attached to a cardboard protractor. They will then "sail" to the nearest meridian along their bearing. When they have determined the ending place for their turn they will log their position in longitude, latitude and the current time in navigator's or 24-hour time. If the time is 8:25 a.m., the navigator's time is 0825. Times after noon are "12 plus" the regular time, as 1:25 p.m. is 1325. Student logs should have headings as illustrated below.

Example Log

Name

turn	time	longitude	latitude



If you use the Yacht Race Chart provided in the pocket, each turn will take players approximately 1 degree of latitude or 60 nautical miles. To make the game playable, the chart should be enlarged by making the copy from the pocket into an overhead transparency. Then it may be traced by students as an enlargement from the overhead projector onto shelf paper. One large chart is sufficient for a team of four to six players. If you wish to order "real" navigator's charts, the ideal choice for this game chart No. 13006 (West Quoddy Head to New York). Chart prices vary, order a current price list and chart catalog from:

Distribution Division
National Ocean Survey
Riverdale, Maryland 20840
Phone 301-436-6990

With "real" charts you will need to assign your own rules for distance traveled in a turn.

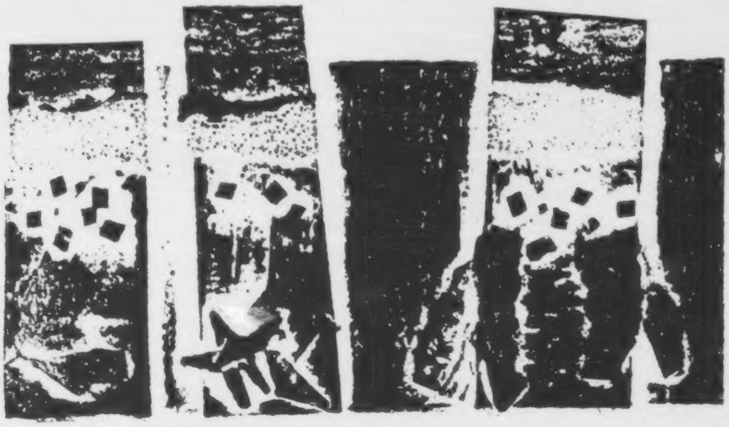
Play moves around the chart table, clockwise. Each player spins the protractor spinner to find the bearing and then locates the bearing on the chart and finally finds where the bearing intersects the closest meridian. Each player then logs his/her position and play proceeds to the next player. Each group chooses its own course, for example Portland, Maine to Yarmouth, Nova Scotia. The first player to reach the destination wins. The protractor spinner simulates the wind and is random so players often will sail in *circles*. If a "spin" bearing would require a player to move his/her vessel across land (islands may be in the way), they simply stay put and re-log their previous turn's position.

The Yacht Race chart, protractor spinner and arrow face and cardboard course protractor plotter face are provided in the pocket. Spinner and plotter need to be reinforced with cardboard.

You may wish to purchase clear plastic protractors for this game. One supplier is:

C-Thru Ruler Company
6 Britton Road
Bloomfield, Connecticut *Model No. 255*

Z is for Zones



In general, a zone is any region or area especially set off by some boundry. When applying this term to the coast one can sometimes see the different zones by examining the various plants and animals, and their vertical distribution. These zones, sometimes referred to as regions or bands, develop from the varying environmental conditions present in the area. Some of these zones have been given names according to the most dominant organisms found in them. In these NNEMEP units we will commonly use littoral zone names. Littoral is from the Latin word for beach, and has historically been used to mean the upper part of the continental shelf. There is no single set of zoneation names which are recognizable as best. We have selected the following names for the regions or zones on the rocky surfaces exposed between the tides; *supralittoral zone, littoral zone, midlittoral zone* and *sublittoral zone.* Once you become familiar with these zones and the organisms within, you and your class may wish to apply your own zone names to the rocky shores as well as the sandy shore, shingle (or pebble) shore, and the muddy shore.

Your study of marine animals will basically take place in the intertidal region, which is that part of the shore found between the highest and lowest of spring tides. This region includes the littoral and midlittoral zones. The supralittoral zone extends above this region and the sublittoral is found below it.

Supralittoral Zone

The supralittoral zone, which is sometimes called the upper shore, includes a splash zone at the upper limit which occasionally gets wet from the sea spray. If the area is bare rock, orange or green lichens may grow here which are easily seen. If you use a hand lens, you will discover that a lichen is made up of two microscopic organisms which help one another, or have a symbiotic relationship. One is a green algae which provides food for the lichen while the other is a fungus which absorbs water and provides a substrate. There are also different types of plants and shrubs which inhabit the part of the splash zone which has a modicum of soil. Mosses, beach peas, rugosa roses and glasswort are a few examples of these plants. Mostly land dwelling creatures are found in this area such as spiders, pill bugs and other isopods, terrestrial mites, and certain kinds of snails.

Littoral Zone

The next rocky shore zone is the littoral zone, also called the black zone. It is in this area that we find rocks covered with a very thin mat of microscopic blue-green algae, which, when concentrated or damp, make the rock appear black or dark green. Animals of this zone are marine species that can breath air or at least spend some time out of the water, and are capable of maintaining a certain amount of moisture in and around their bodies. One such inhabitant is the rough periwinkle, *Littorina saxatilis*, which has distinct whorls in its shell and is light gray in color.

Periwinkles have trap doors called opercula which when closed, trap moisture in and reduce the drying out effects of the sun and extreme temperature. This enables periwinkles to travel upward into the supralittoral zone as well as down into the midlittoral zone. The limpet, commonly called Chinaman's hat, is sometimes found in this zone. However, this animal preserves its moisture by using a strong muscular foot to adhere to the rocks. Both periwinkles and limpets obtain food by scraping blue-green and green algae from the rocks with scraper-like tongues called radulae. Limpets, like perwinkles, are also found in the next zone called the midlittoral zone or the middle shore.

Midlittoral Zone

In the upper part of the midlittoral zone, sometimes referred to as the ***barnacle zone***, barnacles grow in such heavy concentration that they create a white uniform band. Another species of barnacle usually grows below this band in heavy brownish-yellow concentrations. The only time that you can clearly see part of the barnacle animal is underwater at high tide when the shell opens and its six pairs of lacy legs come out to capture food and oxygen. During March and April, the larval forms of these animals are swimming in the sea to find a suitable area for growing. After attaching themselves to rocks, they change their body form to become adult barnacles. Although it is difficult to tell, barnacles are arthropods or crustaceans like lobsters and crabs. Because of where they live, however, barnacles need to be able to adapt to adverse weather conditions. Their conical shells and strong cement enable them to withstand tons of pressure from the waves. They also close their doors so securely that they can stay alive for long periods of time exposed to the extreme cold of winter or the baking hot sun of summer.

The roving bandit of the high end of the midlittoral al zone is the dogwhelk. This carnivorous and at times cannabalistic organism is about the size of a common periwinkle, but the shape is somewhat pointed. Turning this creature over on the foot side a noticeable groove is found around the opercula (trap door) region. This accommodates a tubular structure called a proboscis which is inserted through a tiny hole that it drills into barnacles or blue mussels. The dogwhelk, like the periwinkle, has a toothlike radula but it is better adapted for drilling holes than that of the periwinkle. It also releases a chemical enzyme to soften the shell of its prey which greatly aids the drilling. Many shells of dead whelks have these perfectly round holes drilled in them because they have been eaten by others of their own kind.

Besides having a pointed spire, a dogwhelk can be distinguished from a periwinkle by the shape of its operculum. The dogwhelk has an oval shaped operculum whereas that of the periwinkle is round. The color of the dogwhelk shell, which varies from all white to a pattern created by bands of brown and tan, seems to be determined by what the whelk eats. In late spring and summer you may discover the conical eggs of the whelk which are laid in clusters in rock crevices or on the base of seaweeds.

Also in this barnacle subzone is a limpet. This gastropod or one-shelled, one-footed mollusk is planktonic when young, and like the barnacle, assumes a conical shape when it becomes a settled adult. Its resemblance to the barnacle, however, stops at this point. The low contour of the limpet's shell and its flattened broad shape makes this animal very well adapted to a wave-washed zone. The limpet has a very large fleshy foot under the shell which is easily seen when the animal is attached to the wall of an aquarium. By using its foot, the limpet attaches itself to rocks and moves about when grazing on algae which is its primary food.

We also find small juvenile or adult blue mussels in dark crevices of the rocks. If the area is optimum for growth, mussels will grow in a distinct horizontal band. Mussels are related to other two-shelled organisms, called bivalves, although the foot is very much reduced. The common name of this animal comes from the fact that it is generally covered by deep violet to blue-black colored skin. This horny layer of protein often wears off when the animal dies exposing the light colored shell beneath. One peculiarity of the mussel is that it has byssal threads, resembling a threadlike beard, which it uses to attach itself to rock pilings and small stones. Since these protein fibers may be made or absorbed at will, mussels may move from one area to another. These byssal threads also provide shelter for small crustaceans and worms.

One kind of crustacean found among these threads, an amphipod called *Hyale mussoni* (the sea scud), is orange, has a body compressed on the sides, has small black eyes and usually hops when touched. Small round worms called hemotodes, segmented worms called oligochaetes, and ribbon worms may also be found among the byssal threads.

Perwinkles may also be found in this part of the zone, sometimes growing so abundantly that they form a narrow band. Other forms of life may wash up into this region and some of those listed above may be completely absent depending on the area, the exposure to wave action, and the slope of the beach.

As we move further down the midlittoral zone, we come to a part called the ***rockweed zone***. This zone is dominated by two types of brown algae — bladder wrack or rockweed and knotted wrack. Rockweed is olive-green to dark green, regularly branched, and has a tough leathery body. The branches may be somewhat spiraling and usually have paired air bladders with a central structure or mid-rib running down the length of the body. Reproductive structures may also be found at the tips of the plants from late spring through summer. Although rockweed, like all seaweeds, has no true roots, stems of leaves, it has a stem-like structure called a stipe and root-like structure used for attachment called a holdfast.

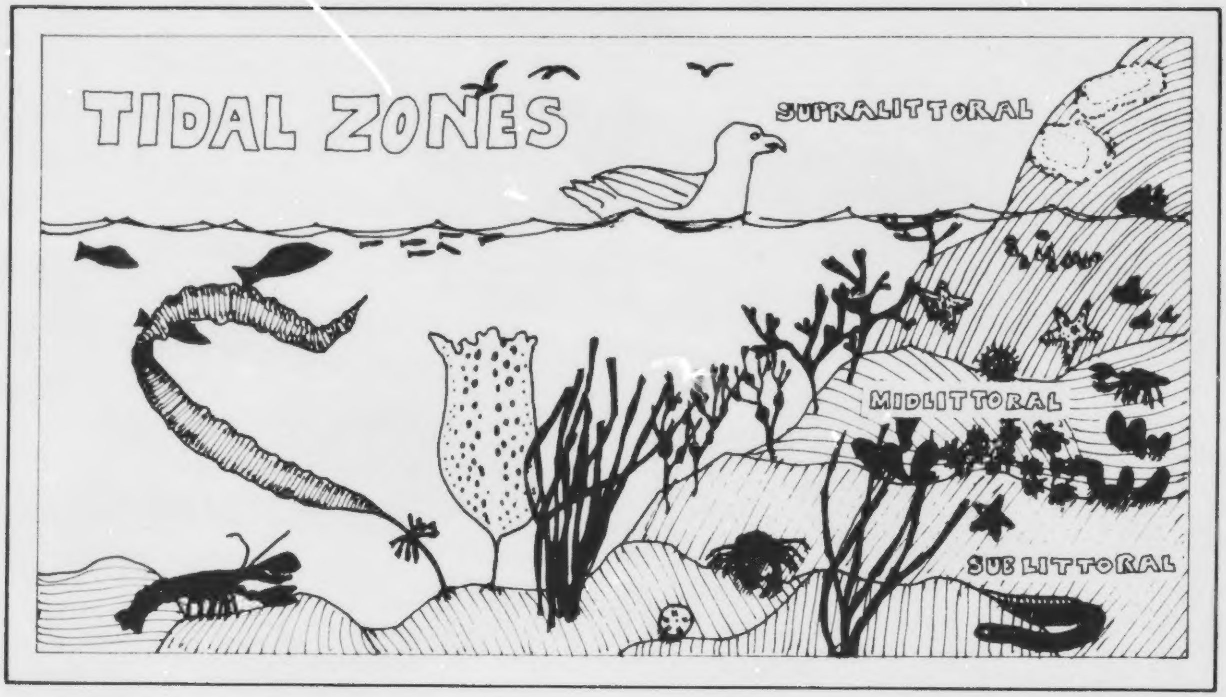
Intermingled with the bladder wrack, and appearing lower down in the rockweed zone is the knotted wrack. This seaweed, which is a perennial, is more stringy, very tough and is olive-green to yellow-brown in color. It, too, has small air sacs along the length of its branches which aid in flotation. However, in contrast to bladder wrack, knotted wrack has no mid-rib and the holdfast is disc shaped and very small.

Because the rockweed zone has much seaweed which retains moisture when the tide is out, many animals find protection here. Looking carefully under the seaweed, you may find green crabs, limpets, periwinkles, snails, beach hoppers, blue mussels, dogwhelks, scaleworms, barnacles, and occasionally sandworms. Hydroids, *Hydractinina echinata*, which may be found growing on seaweed, discarded periwinkle shells or moon-like snail shells inhabited by hermit crabs, are also found in this zone. Some hydroids, which resemble plants more than animals, grow in branches with the ends of their polyps equipped with flower-like pink and red tentacles.

Another animal found in this zone is the coiled tube worm or *Spirobis*. Although this animal superficially resembles a barnacle, if you examine it more closely you will discover that it has a white coiled shell made of calcium. When the tube worm is under water it relaxes and its tentacles may be seen. But, when disturbed or out of water, it closes off its tube with an airtight operculum. When tube worms appear on rockweed, they give it a white spotted appearance. Some may also be found on rocks, on the shells of snails, and on crabs. You will notice that some kinds of tube worms have coils which form in a left-handed pattern, and others have coils that develop in a right-handed swirl. The individual shell pattern of a tube worm, along with its preference for habitat, determines what species each one belongs to. Tubeworms also have an interesting reproduction and larval development. They breed their young in an egg sac inside their shell which hatch out after a month or so. This usually occurs in June or July during the full moon, at which time the pin, ciliated larval forms swim to the surface waters and search for adult populations. When they find a suitable habitat, they spin a calcium tube to live in within twenty-four hours.

The lowest level of the midlittoral zone is called the ***red algae*** or ***Irish moss zone***. These algae are usually found on seashores exposed to the open ocean and offer a living environment for creatures not found in the other zones. Irish moss is a perennial seaweed which grows in dense colonies, on rocks seen at low tide or sometimes in twenty or more feet of water. The color of this plant may vary from bleached-out white to yellow-green or even a pinkish-green. Although its primary red pigment may be masked by other pigments to give it a slightly different hue, Irish moss is still considered a red algae. It is bushy, double-branched, has many blades which become very slender toward the holdfast, and is usually from seven to fifteen centimeters in length. Around its holdfast you may find scale worms, round worms, and little amphipods as well as small blue mussels and periwinkles.

There are many other species of red algae growing in this zone. Coralline algae is one of these, and this algae can take two different shapes; as an



encrusting plant on rocks, giving them a reddish color, or as a stony plant that grows upright (from 5 to 10 centimeters) in the lower midlittoral zone. Another kind is laver, a very thin, reddish-brown leathery marine algae that resembles the green sea lettuce, *Ulva*. The sea lettuce can be found in tide pools higher up in this zone, and the laver can be found growing on large, coarse rockweeds and kelps.

Another red algae, called dulse, grows with blades extending up to fifty centimeters with an average of about twenty centimeters. When dulse is wet, it feels slippery and has a very tough, leathery texture. It may be found on other plants, rocks or even on mussels.

Further down the red algae zone, you may find other forms of plant and animal life in crevices, overhangs or isolated pools. One organism is the crumb-of-bread sponge, which filters sea water through its porous body to obtain plankton. Another animal you may discover is the green sea urchin which may be distinguished by its globular shape and its blunt spines. The urchin's mouth is located on its bottom side, and, by turning it over, you may observe how it chews. Its beak-like jaws are used to obtain food by scraping algae off rocks as it moves along on its tube feet. If you look in the upper shore zone you may find pieces of the sea urchin shell found here because they have been dropped by gulls who do so to feed on the inside flesh. You may find its whole skeleton called a test or part of its mouth supportive structure called Aristotle's lantern. By observing the shell and the structure of the urchin you will discover the symmetry of its design.

Starfish may also be found in this zone. These animals have tough skin, and like the sea urchins, have spines and tube feet. The common starfish is usually distinguished by its green or blackish-green color. The northern starfish also has five arms, but there are no definite lines on top of them. Also, its body is not as firm as the other starfish. The lavender starfish and the purple starfish are other names for this organism.

Other less commonly found starfish are the brittle star, sometimes called daisy star, and the blood star. The brittle star is, as its name implies, quite fragile and is recognized by its serpentine rays which may be seen around the rocks where it seeks protection. The blood star is crimson red and resembles the common starfish except that its tube feet are not as conspicuous and only occur in rows of two instead of in rows of four.

An interesting characteristic of starfish which you may observe in an aquarium is their strange feeding behavior. The starfish usually feeds in a humped-up fashion with its legs wrapped around a soft shell clam or a mussel. Using suction, it attaches itself firmly to the two shells with its tube feet and pulls the shell apart by exerting continual pressure. With the help of muscle relaxants that the starfish releases into the water, the mollusk tires and the shell is partially opened. The starfish then turns its stomach through its mouth and digests the soft body parts of its victim internally. All that is left after this feeding is an empty shell partly opened. Another interesting characteristic that may be noted if you observe starfish over a period of time is their ability to regenerate rays. Part of the central circle around the mouth must be present for this to occur.

Near or below the low tide mark in the midlittoral zone, one may find several types of sea anemones. One of these is a flowering anemone whose body consists of a stem-like sylindrical body with petal-like tentacles. When the anemone is relaxed and covered by water, its tentacles extend, enabling it to capture minute life forms such as plankton. These tentacles have special stinging cells armed with a toxin which paralyzes the prey, although they are harmless to people. If the anemone is disturbed, it withdraws its tentacles into its body.

Another mollusk of this zone is the chiton. Like the limpet, it has a very muscular foot and feeds on microscopic vegetation. However, it is unmistakably different because it has a shell composed of eight overlapping plates.

Sublittoral Zone

The last rocky shore zone is called the sublittoral or ***laminarian zone***. The upper limit of this area is uncovered only in extreme tidal conditions and the lower limit, which is sometimes called the scuba zone, is never uncovered. Although, for the most part, the flora and fauna of this zone are under water, you may observe several kinds of kelp or laminarian seaweed from the surface. One of these kelps resembles the fingers of a large hand and another looks like a very long ribbon. Since the plants and animals living here are frequently subjected to the pounding of waves at the top of the zone, they must be well attached. The kelps have holdfasts which strongly hold them in one place.

The alternative shore types where you may find animal and plant life are the sandy shore and the mudflat. A shingle or pebble beach offers very little security for either plant or animal life because of the grinding action of tumbling stones.

Art Activities

This group of activities was developed to allow the students to express themselves creatively through the use of basic materials found at the shore and brought to the classroom. It is also intended to be used *in conjunction with other marine learning experiences*. These activities may be used separately whenever art is called for in your curriculum. It is recommended that the activities be incorporated into a total unit, such as "The Rocky Shore," or coordinated with the reading of a book.

In collecting materials to be used in these arts and crafts activities, emphasize that students should collect no more material than they will need to complete the activities. The only material the students should be encouraged to collect an excess of is beach trash.

Basic Materials
Below are some of the materials you will need. Except for the materials collected at the beach, most of them are available in hobby and art supply stores. Think ahead; collect in the summer and fall!

Shells — a wide variety of shapes and colors

Driftwood — a variety of shapes and sizes

Beach vegetation

Beach Glass — fragments of glass that have been made smooth by wave and sand action

Pebbles, Stones, and Rocks — a variety of colors, sizes, and shapes

Adhesives — white glue (such as Elmer's Glue-All), rubber cement, school paste, household cement (such as Duco), epoxy, etc.

Paintbrushes — several sizes

Paper — construction paper, newsprint, aluminum foil, tissue, oaktag, rice paper, paper, cardboard, poster board

Drawing and Painting Supplies — crayons, chalk, charcoal, pastels, pencils, tempera paints

Cutting tools — scissors, paper cutter, utility knife, wire cutters

Spray Shellac and varnish

Plaster of Paris

String, heavy thread, wire, yarn, fishing line, dental floss

Fabric scraps, felt, pipe cleaners, etc.

Seashore Bulletin Board

Materials
shelf or blank newsprint paper
white glue
construction paper
felt tip markers

Directions
After returning from a field trip for whole class or small group, spend a class session grouping all the dry and non-smelly materials collected into the zones they represent. Assign teams to assemble a collage of materials for each zone. Construct the class poster or mural so that each task team receives their section and decorates it to tell the story of their zone. For a variation, you may want groups or individual students to write a paragraph about their reflections on each zone. This can be especially interesting if they write their story as an explanation of their group effort but with each student writing about a different organism. This combination of writing and art makes zone learning come alive.

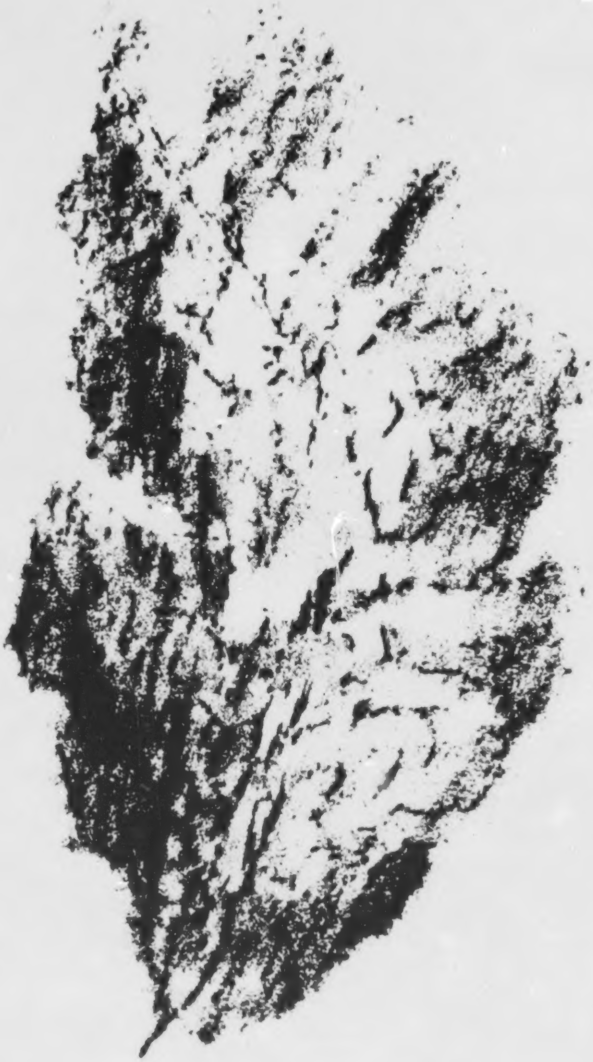
Seashore Rubbing

Materials

flexible paper such as rice paper or special rubbing paper
dark crayons or graphite sticks
clip boards or other portable working surfaces

Directions

There are many marine items which may be too prone to decay for your students to bring them back to the classroom. Such items as sea weed (algae), dead crabs and other hard or semihard materials may become pictures without drawing. Place the item to be rubbed on a firm, flat surface. Mold the rubbing paper gently to fit the curves of the item being rubbed. Rub slowly with the crayon or graphite stick only on the parts that project from the background surface. Colors may be chosen to correspond to the natural, living color of the organism being rubbed. You may want to use rubbings as a way to enhance a shore bulletin board, or you may want your class to make booklets describing sea life of interest to them with a rubbing as an illustration for each organism. If you want to spend a little more for materials, kits of rubbing crayons and rubbing papers are available from art supply shops.



Shell Printing

Materials

a variety of shells (works best with sand dollars and other *flat* shells)
newsprint
paintbrushes, wide, stiff
non-toxic paints, water soluble *only*
newspaper

Directions

1. Cover the work area with newspaper.
2. Choose several interesting shells you wish to print with. Plan a design.
3. Using a paintbrush, cover the shell evenly with paint.
4. Place the shell on the newspaper and gently press the newsprint down on the shell. Rub back and forth gently until the impression of the shell is on the paper. Repeat this step with the other shells.
5. Let the finished paint dry.

Variations

1. Cut out the prints and mount them on a contrasting piece of paper.
2. Combine shell printing with painting, or include shell prints as part of a collage.

Driftwood Sculpture*

Materials

driftwood, in a variety of shapes
shells, pebbles, dried beach grass
glue

Directions

1. Find a piece of driftwood that resembles an animal.
2. Add decorative touches so that it resembles the animal even more.

Variations — Natural Driftwood Sculpture
Select an unusual piece of driftwood. Glue pebbles, shells, and beach grass to it in an artistically pleasing manner.

**Can be used with unit on Native Americans or careers in crafts.*

Pressed Vegetation Collage*

Materials

leaves, beach grass, seaside flowers, etc.
tissues
tweezers
toothpicks
white glue
heavy poster board
large book such as telephone directory, catalogue or dictionary

Directions

1. To prepare the vegetation for drying and pressing, place it between two pieces of newspaper. Make sure the vegetation is flat.
2. Place the newspaper and vegetation between two large books for about a month, or press in a plant press for 4-5 days. (Steps 1 & 2 should be accomplished by the teacher before beginning the project with the class.)
3. Carefully remove the pressed and dried vegetation from the book and arrange it in a design on the poster board.
4. Using tweezers, carefully pick up the vegetation. With a toothpick, dot a small amount of white glue on the pressed material. Place the pressed materials on the poster board.

Variations

1. Using a picture frame, glue the pressed material on the cardboard backing and cover with glue.
2. Pressed vegetation may be glued onto plain note paper.
3. Pressed vegetation may be glued onto flat pieces of driftwood or boards collected at the beach.
4. Arrange leaves, grasses, etc. on a piece of white, or colored, 12" x 18" drawing paper. Cover the paper and decorations with clear contact to make a place mat.

**Use with unit on plants. Use pressed plants to paste onto pictures students draw.*

Sand Painting*

Materials

fine sand
white glue
oaktag or heavy cardboard
water
paintbrush
pencil
trays for sand
brush and dustpan

Directions

1. With a pencil, lightly draw a simple design on the oaktag or cardboard.
2. Mix equal amounts of glue and water.
3. Paint a small portion of the design with the glue and water mixture and sprinkle sand on it. Shake off the extra sand. Continue until the design is covered with sand.

Variations

1. Use colored sand. You may either purchase colored sand from a hobby supply store or make your own. To color sand, mix sand with acrylic paint and water and leave it to dry for several hours. Stir the drying sand occasionally to prevent lumps from forming. Food colors are good for coloring white Southern sand, which are often available from regular science supplies.
2. Make a sand-painted mural. Everyone in the class could contribute one scene to a large picture.
3. Lightly outline a desired shape with crayon in a styrofoam meat tray. Sand paint that design, or sand paint "free-hand" using the sand discussed above, or using colored aquarium gravel. Q-tips can be used to apply undiluted Elmer's glue to the meat tray. Masking tape can be used to mount half a paper clip to the back of the meat tray for use in hanging.

**Read a book on a variety of seashore creatures. Hand out an outline of various creatures and use for sand painting. The very use of beach sand for paintings will generate marine-related questions and awareness. Therefore, apply the sand-painting activity to any curriculum area which is in need of an art activity. For example, utilize for large block letter and/or number cards.*

Rocks and Pebbles*

Painted Rock

Materials

large rock
tempera paints
spray shellac
white glue
paintbrushes
yarn, feathers, string, pipe cleaners, felt, macaroni

Directions

1. Wash a rock and let it dry.
2. Choose a marine creature and paint it on the rock. Use one color at a time. Allow each color to dry thoroughly before using another.
3. When the paint is dry, spray the rock creature with shellac and let it dry.
4. To make hair, whiskers, antennae, feet, tails, ears, tongues, etc., use feathers, yarn, string, felt, pipe cleaners, small pebbles, etc. Be creative!

**Use to reinforce science unit on rocks and minerals; following a field trip to the shore; after reading a book on the rocky shore or volcanoes (or other earth science-type book).*

A

My Special Critter

Name: ____________________

Grade: ____________________

Date: ____________________

My critter is a ____________________

My critter moves about ____________________ centimeters in 10 seconds.

My critter has ____________________ to help it move. It moves by ____________________

My critter gets food by ____________________

My critter looks like this (draw a picture)

My Critter

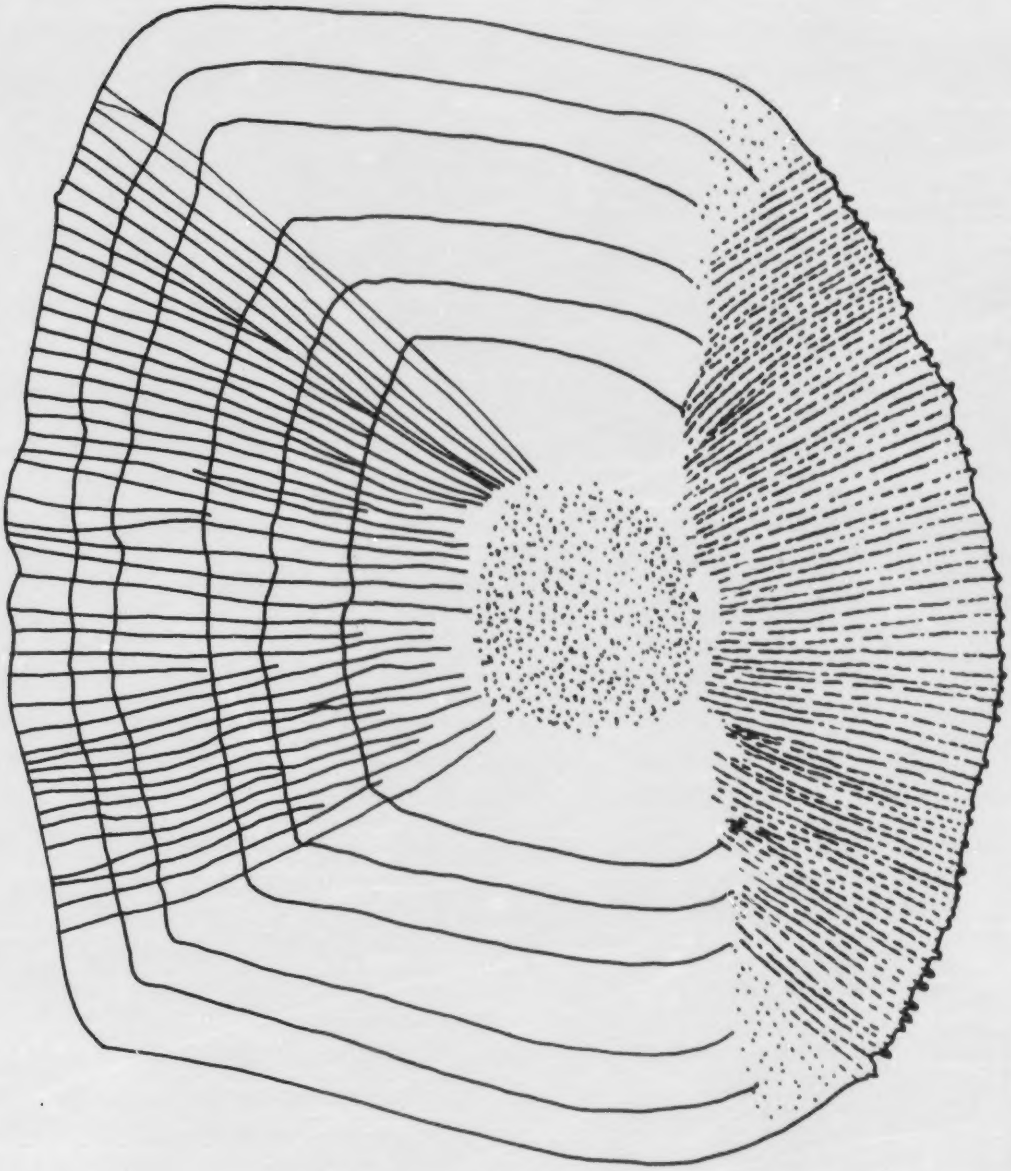
If I were my critter, I would like to live in (or near) a ____________________

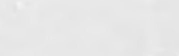
Because ____________________

As my critter looks out at me it "thinks" that I am ____________________

Because ____________________

C

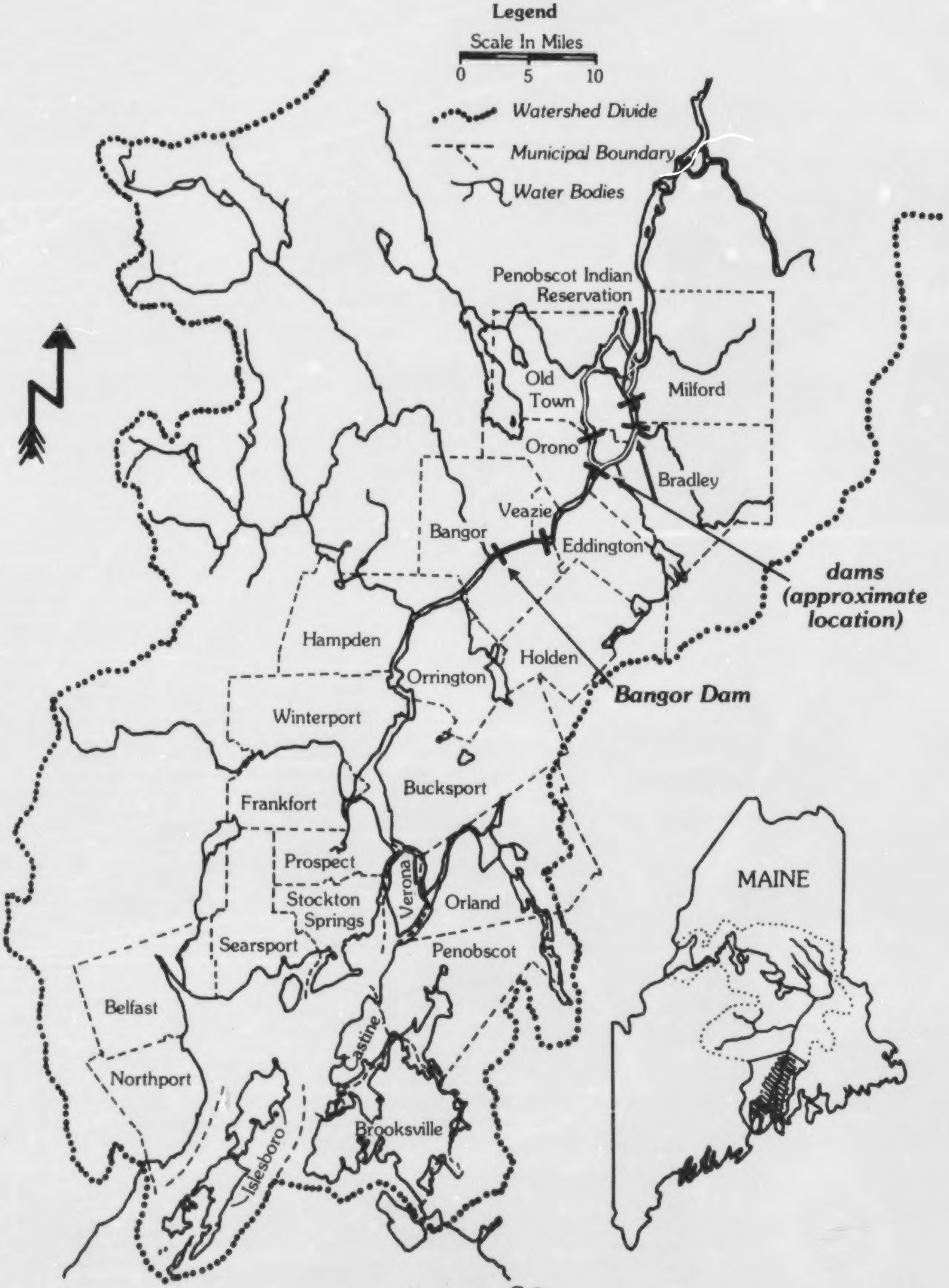




A magnified 6 year old striped bass scale

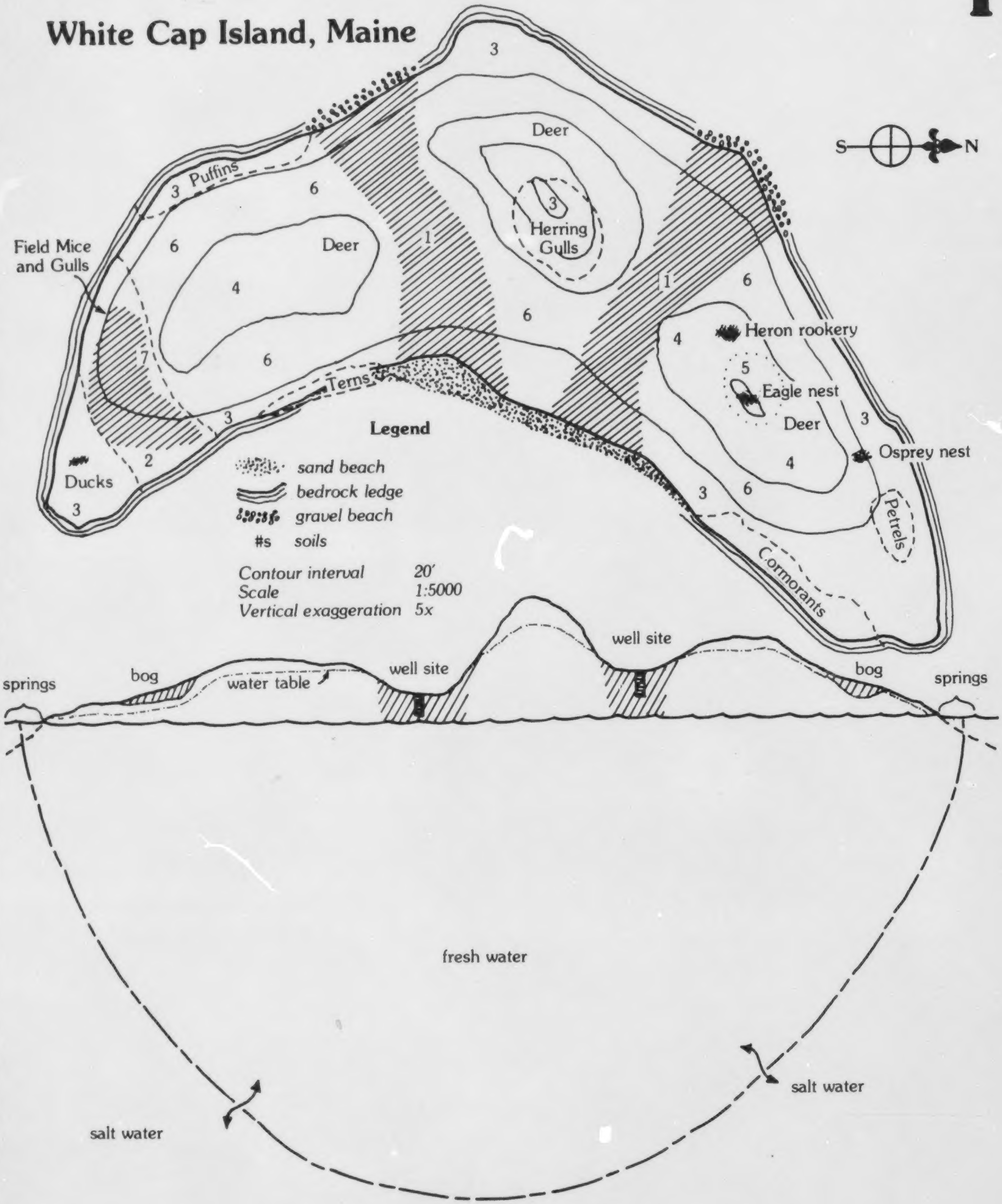
Lower Penobscot River Area Map

E


Legend
Scale In Miles
0
5
10
Watershed Divide
Municipal Boundary
Water Bodies
Penobscot Indian Reservation
Old Town
Milford
Orono
Bradley
Veazie
Bangor
Eddington
dams (approximate location)
Hampden
Holden
Orrington
Bangor Dam
Winterport
Bucksport
Frankfort
Prospect
Verona
Orland
Stockton Springs
Searsport
Penobscot
Belfast
Castine
Northport
Brooksville
Islesboro
MAINE

I

White Cap Island, Maine



S
N
3
Deer
3
Herring Gulls
Puffins
3
6
Field Mice and Gulls
6
Deer
4
6
1
1
6
7
6
Heron rookery
4
5
Eagle nest
Deer
3
Osprey nest
4
6
3
Terns
3
2
Ducks
3
Petrels
Cormorants
Legend
sand beach
bedrock ledge
gravel beach
#s soils
Contour interval 20′
Scale 1:5000
Vertical exaggeration 5x
springs
bog
water table
well site
well site
bog
springs
fresh water
salt water
salt water

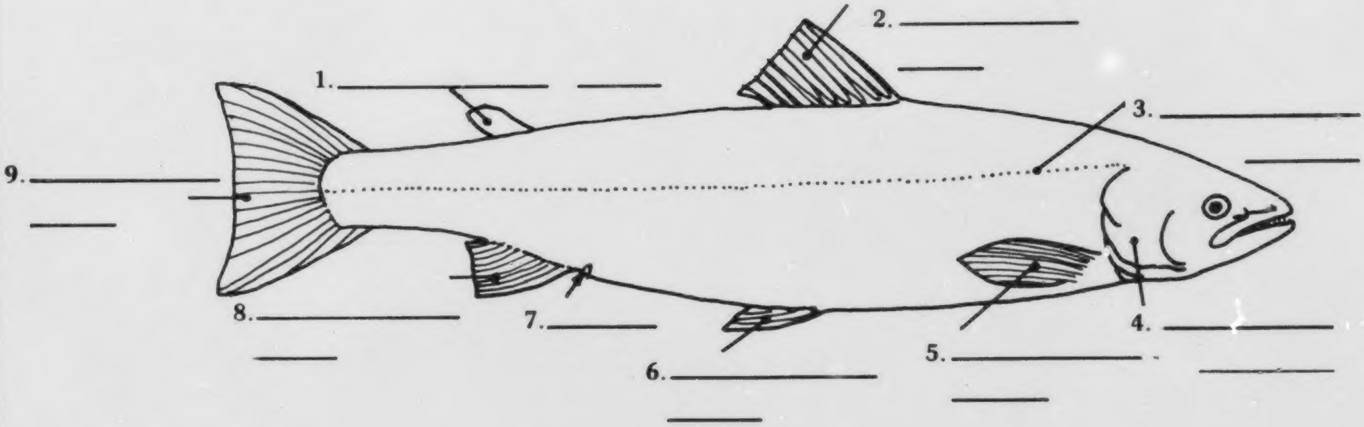
F

Salar Quiz

NAME ____

1. The spawning ground is called the ______________________________ .
2. A female salmon lays ______________________ eggs per pound of her weight.
3. I hatch and feed on the yolk sac. I am ______________________________ .
4. I look very much like a brook trout. I am ______________________________ .
5. The parr can be distinguished from the brook trout by its ______________________ .
6. I turn silver and swim to the ocean. I am a ______________________________ .
7. I have spawned in the river and spend the winter in a pool of the river. I am a __________ .
8. I return to the river and spawning ground after one year in the ocean. I am a __________ .
9. A mature male salmon has a ______________ , ______________ lower jaw.
10. Three things that are bad for *Salar* are __________, __________ and __________ .
11. Two ways of catching salmon by commercial fishermen are __________ and __________ .
12. Three ways to help Salar by management are __________, __________ and ______ .

Salar Diagram



adipose fin
dorsal fin
lateral line
gill cover
pectoral fin
ventral fins
anus
anal fin
caudal fin

Atlantic Salmon Worksheet

Please answer the following questions. They are multiple-choice. Underline the correct answer.

1. The mouth of a river where the tide meets the current.
   a. breeding ground
   b. estuary
   c. spawning area

2. Atlantic salmon can return to the river __________ to spawn.
   a. once
   b. twice
   c. several times

3. A salmon that returns after one year is called a
   a. grilse
   b. alevin
   c. parr

4. The spawning area must contain
   a. gravel bottom
   b. clay bottom
   c. solid rock bottom

5. A series of minute pores forming a line running along each side of the fish; the nerve endings in the pores sense disturbances in the water.
   a. lenticel
   b. lateral line
   c. kelt

6. We can tell a lot about the life history of a salmon by an examination of its
   a. dorsal fin
   b. gills
   c. scales

7. Any of the thin flat, hard plates covering many fish.
   a. gills
   b. alevins
   c. scales

8. Fish ladders help salmon to
   a. migrate upstream
   b. find food
   c. spawn

9. A process in which a mass of eggs or sperm is emitted by a fish.
   a. spawning
   b. tagging
   c. scaling

10. Although a pair of spawning salmon will lay 3,000-20,000 eggs, only __________ of their offspring survive to spawn.
    a. 2
    b. 100
    c. 1,000

White Cap Island, Maine

Description: White Cap Island is located 9 km from the mainland. It has a surface area of 500,000 sq. meters (approximately 125 acres). The island is crescent shaped. White Cap Island has a rolling topography with three hills and steep slopes along its shoreline (see map).

Geology: The island is made up of surficial materials composed of reworked glacial drift. Surfical deposits are important to man because they usually support the best soils on the islands, they are used for house foundations and sewage disposal systems, and freshwater wells are more easily constructed in unconsolidated surficial deposits than in bedrock.

The bedrock making up the island is a pink, coarse-grained granite. This granite bedrock has a high resistance to erosion and a moderate to high bearing capacity. The unconsolidated surficial deposits have a low to moderate bearing capacity and are very susceptible to erosion. The rising sea level is eroding these deposits.

Shoreline Types: The shoreline types along White Cap Island are primarily composed of ledge. There are two gravel beaches and one sand beach located at different points on the island. The major source of materials for these beaches is surficial material eroding off the island.

Rocky shores differ from sandy shores in that rock shorelines house many more organisms than sandy beaches. Most of the organisms on a rocky shoreline are either attached to the surface of the rocks, or are found under or in between the rocks. Sandy beaches constitute a more rapidly shifting substrate than rock. Much of the life associated with a beach burrows into the sand and is not readily visible.

Ground water: Fresh water is an important factor influencing plant and animal habitation. It is available from precipitation (rain and snow) that infiltrates the soil and migrates slowly downward, filling spaces between soil particles and minute openings in the joints and fractures in the bedrock. The water table is the upper surface of the saturated zone. All water in this saturated zone is called ground water.

The ground water table follows the topography of the island, being higher under hills and lower under valleys. Its level at any one locality represents a balance between recharge from precipitation, and discharge from springs, seeps, and wells. The elevation of the water table varies seasonally in response to different amounts of precipitation (usually less than 3 meters). Because the water table is higher than mean sea level, there is an overall outward flow of ground water from an island (i.e. springs).

Fresh water is less dense than salt water and tends to float upon it. Analogous to an iceberg, a body of fresh water associated with an island is much more extensive below sea level. Because the fresh water flows seaward, the interface between fresh water and salt water is displaced seaward. It is this interface displacement that allows fresh water wells to be constructed only a few meters from high tide. Drilling wells too deep, or over pumping them, would cause salt water to rapidly intrude and contaminate the fresh water supply.

Islands do not have unlimited supplies of fresh water. The supply is renewed only through precipitation. As a result, the available fresh water supply must be developed and used wisely. It is best to construct wells as far back from the shore as practical and to use them only for domestic purposes. Once salt water intrusion has occurred, a lengthy period of time may be required for natural ground water to flow to flush the salt out. Perhaps the most economical and reliable well sites on this island would either be in the deep, permeable surficial deposits or where springs are found at a safe distance from the shore.

Soil types. The following are the types of soil present on White Cap Island. Consult the map to find the actual location of these soil types.

1. Moderately well drained, greater than 150 cm to bedrock, area on top is gravelly loamy sand. Surface stoniness ranges from non-stony to extremely stony.
2. Cool damp land, less than 50 cm to bedrock. The sandy loam is high in organic matter.
3. Area more than 90% of exposed bedrock.
4. Area more than 50% of exposed bedrock with the remaining area being sandy material less than 25 cm deep (to bedrock).
5. Very poorly drained organic soils. Less than 100 cm deep over the bedrock.
6. These are cool, damp organic soils that have about 20 cm of organic matter over 5 cm of sandy materials on top of bedrock.
7. This area is somewhat excessively drained. The gravelly loamy sand extends 100 to 150 cm till bedrock. The surface stoniness ranges from non-stony to extremely stony.

Vegetation: The vegetation on White Cap Island is dominated by a softwood (white spruce and red spruce) forest. This island can produce wood volumes sufficient to induce commercial harvesting given proper economic conditions. The spruce forest on the coastal islands has significant recreational and wood resource value and endows the island with a special scenic quality.

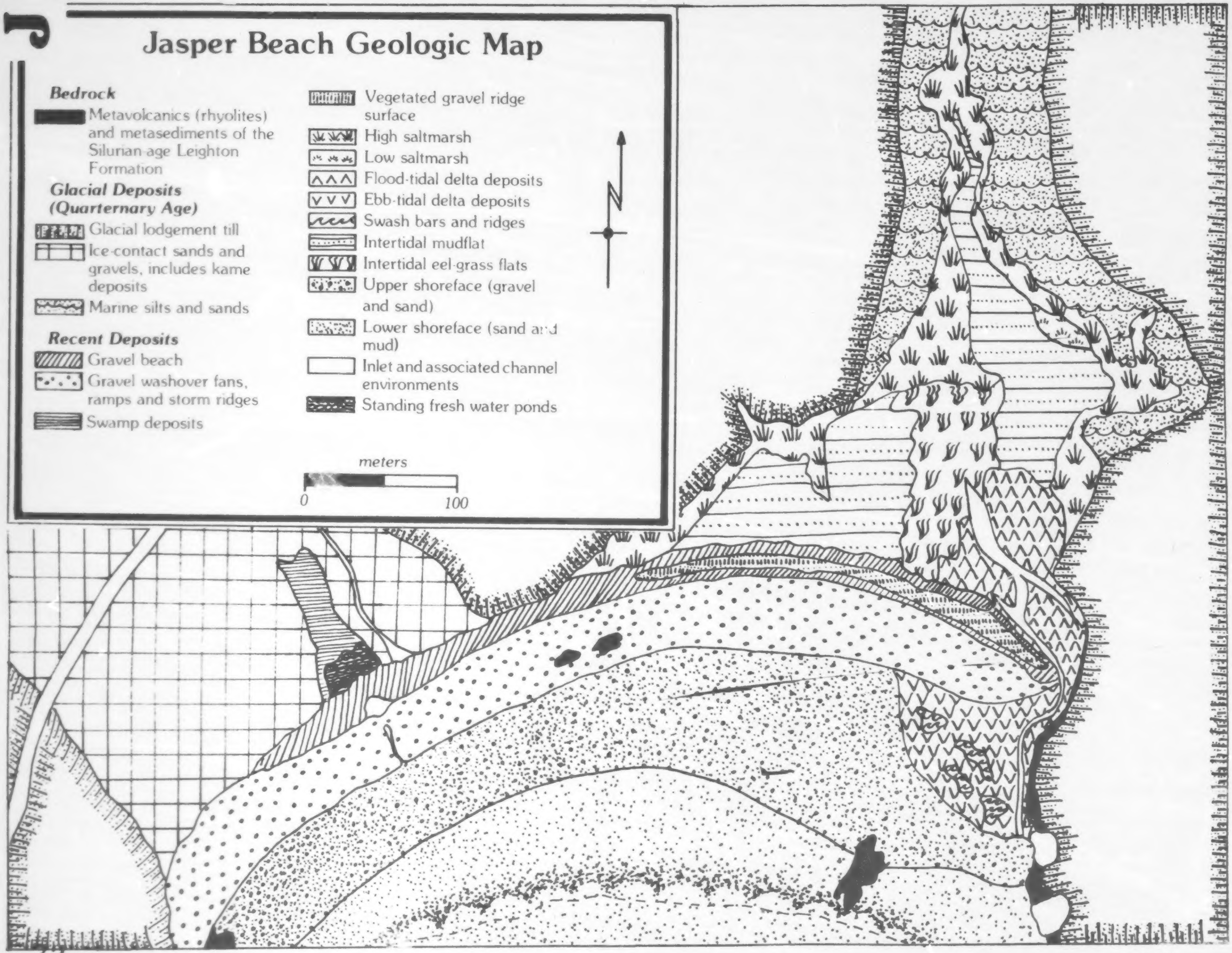
In addition to the softwood forest, there are two small bogs on the island which are located in depressions in the bedrock. These bogs are vegetated with mosses and grasses. There are many small plants on this island not found on the adjacent mainland. This is due to the unique environmental conditions found on the island.

Wildlife: The wildlife population on White Cap Island consists of white-tailed deer, field mice, assorted insects, birds of prey, seabirds (Cormorants, Terns, Herons, Leach's Petrels, Puffins, Osprey, Bald Eagles, Ducks and Gulls).

The vegetation cover and structure of the island determine the best selection factors for the nesting species. The cormorants have built semi-permanent nests on the northeast shoreline of White Cap Island. The terns are also located on the ledges, but they are at a fair distance from the cormorant colony, on the southeast coast of the island. The ducks nest in the shrubby area on the southern tip of the island, the gulls have chosen a grassy site adjacent to the ducks. The puffins nest on the cliffs on the west shore of the island. Herons, bald eagles, and ospreys all nest in the island's trees. The petrels nest in burrows dug into the ground on the northern side of the island where the sod is deep enough for burrowing.

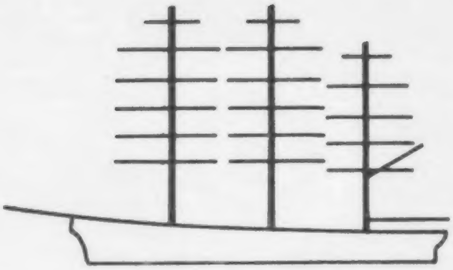
Scenic Value: White Cap Island has, as all coastal islands have, a high scenic value. This island is a prominent feature on the landscape of the region. It is visible from the mainland, from the water and from other islands. As the region is partially dependent on tourism as a source of income, it is in the best interests of the region that the island remain highly scenic.

Jasper Beach Geologic Map

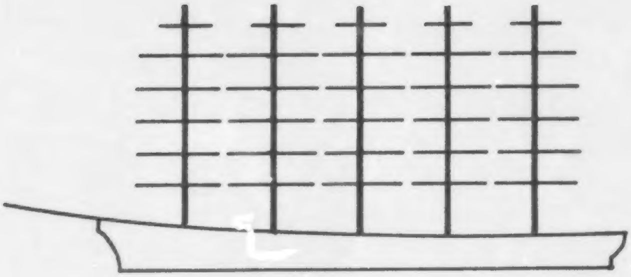


Bedrock
Metavolcanics (rhyolites) and metasediments of the Silurian-age Leighton Formation
Glacial Deposits (Quarternary Age)
Glacial lodgement till
Ice-contact sands and gravels, includes kame deposits
Marine silts and sands
Recent Deposits
Gravel beach
Gravel washover fans, ramps and storm ridges
Swamp deposits
Vegetated gravel ridge surface
High saltmarsh
Low saltmarsh
Flood-tidal delta deposits
Ebb-tidal delta deposits
Swash bars and ridges
Intertidal mudflat
Intertidal eel-grass flats
Upper shoreface (gravel and sand)
Lower shoreface (sand and mud)
Inlet and associated channel environments
Standing fresh water ponds
meters
0
100

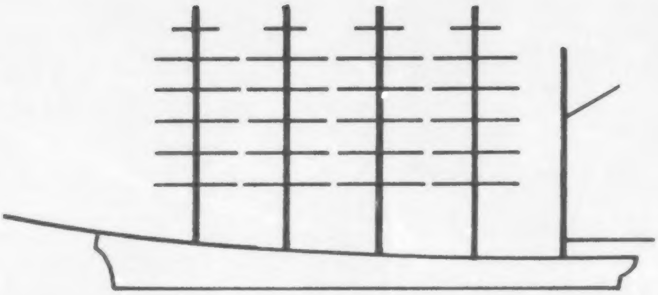
Mast Plans



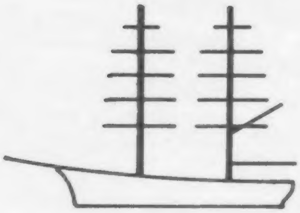
Three-Masted Full-Rigged Ship



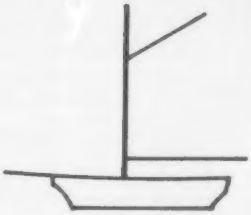
Five-Masted Full-Rigged Ship



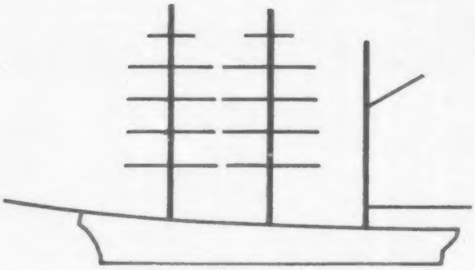
Five-Masted Bark



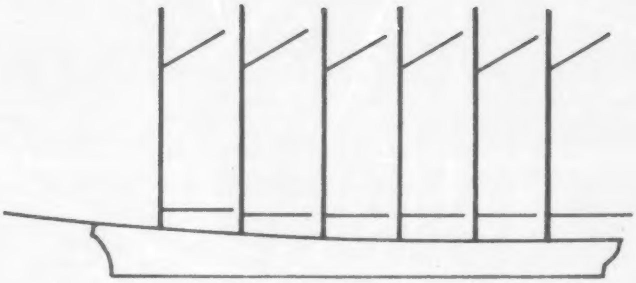
Brig



Sloop

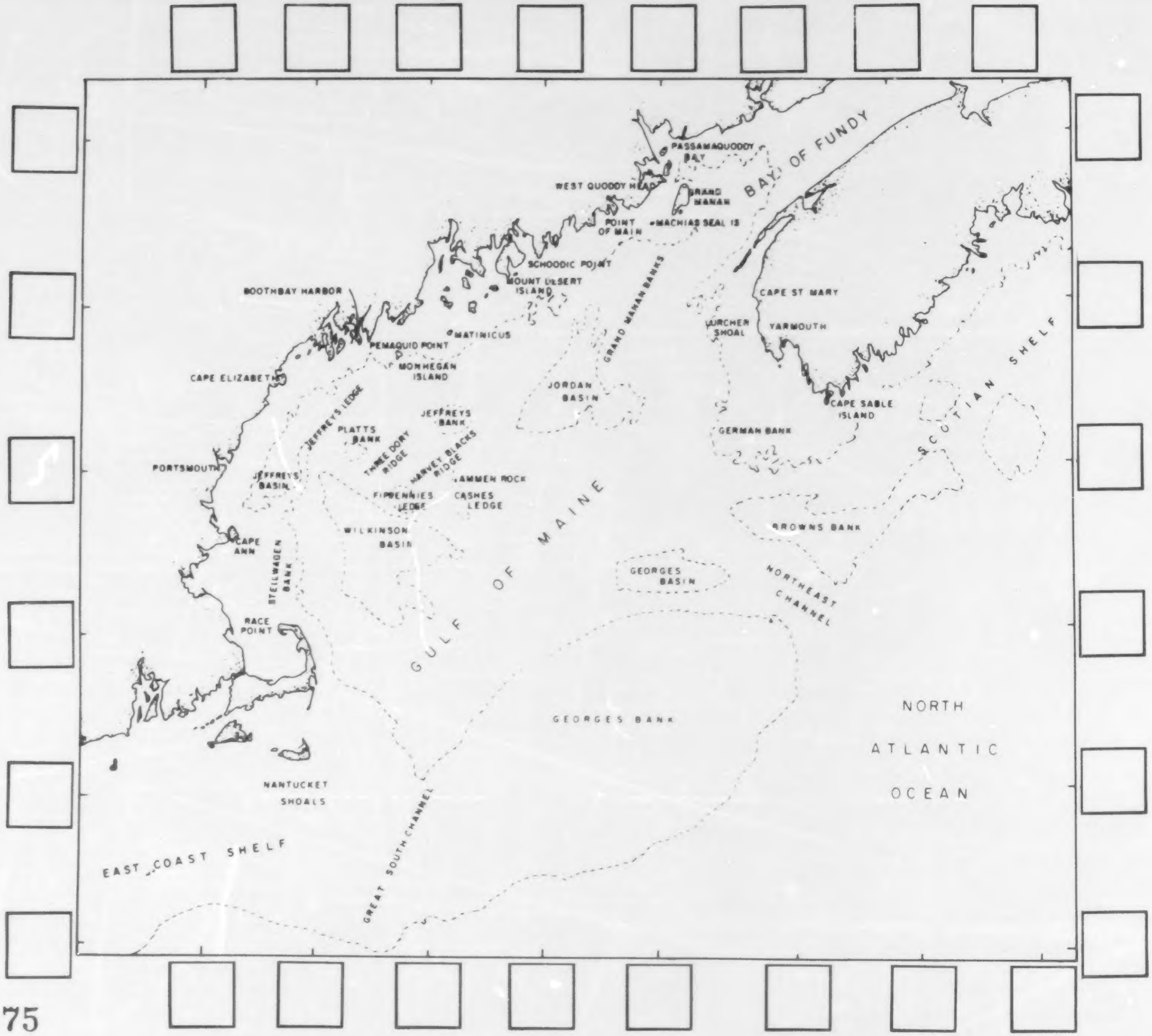


Three-Masted Bark



Six-Masted Fore-and-Aft Schooner

Longitude and Latitude Chart


PASSAMAQUODDY BAY
BAY OF FUNDY
WEST QUODDY HEAD
GRAND MANAN
POINT OF MAIN
MACHIAS SEAL IS
SCHOODIC POINT
MOUNT DESERT ISLAND
BOOTHBAY HARBOR
GRAND MANAN BANKS
CAPE ST MARY
LURCHER SHOAL
YARMOUTH
MATINICUS
PEMAQUID POINT
MONHEGAN ISLAND
CAPE ELIZABETH
JORDAN BASIN
SCOTIAN SHELF
CAPE SABLE ISLAND
JEFFREYS LEDGE
JEFFREYS BANK
PLATTS BANK
GERMAN BANK
THREE DORY RIDGE
HARVEY BLACKS RIDGE
PORTSMOUTH
JEFFREYS' BASIN
AMMEN ROCK
FIPPENNIES LEDGE
CASHES LEDGE
GULF OF MAINE
BROWNS BANK
WILKINSON BASIN
CAPE ANN
STELLWAGEN BANK
GEORGES BASIN
NORTHEAST CHANNEL
RACE POINT
GEORGES BANK
NORTH ATLANTIC OCEAN
NANTUCKET SHOALS
GREAT SOUTH CHANNEL
EAST COAST SHELF

Marine Units Order Blanks

If you would like to order any of the units produced by the Northern New England Marine Education Project, please fill in the following information. These units are available to you at cost ($3.50 per unit), and the postage and handling fee is already included.

Make check payable to: University of Maine at Orono. Send checks for the exact amount to:

Northern New England Marine Education Project
206 Shibles Hall
University of Maine
Orono, ME 04469

# of units requested	*Unit Title*
______	Have You Been To The Shore Before?
______	What Adventures Can You Have In Wetlands, Lakes, Ponds, and Puddles?
______	What Is Our Maritime Heritage?
______	How Do People Use Lighthouses and Navigational Charts?
______	Is Our Food Future In the Sea?
______	Do You Know Our Marine Fish?
______	Do You Know Our Marine Algae?
______	What Are the ABC's of Marine Education?

Total # of Units Requested ______ X $3.50 = ______

Your Name ______

Mailing Address ______
Street or P.O. Box

______
(Village)

______
(State) (Zip)

Please prepay and allow 4 weeks for delivery.

Make check payable to: University of Maine at Orono. Send checks for the exact amount to:

Northern New England Marine Education Project
206 Shibles Hall
University of Maine
Orono, ME 04469

# of units requested	*Unit Title*
______	Have You Been To The Shore Before?
______	What Adventures Can You Have In Wetlands, Lakes, Ponds, and Puddles?
______	What Is Our Maritime Heritage?
______	How Do People Use Lighthouses and Navigational Charts?
______	Is Our Food Future In the Sea?
______	Do You Know Our Marine Fish?
______	Do You Know Our Marine Algae?
______	What Are the ABC's of Marine Education?

Total # of Units Requested ______ X $3.50 = ______

Your Name ______

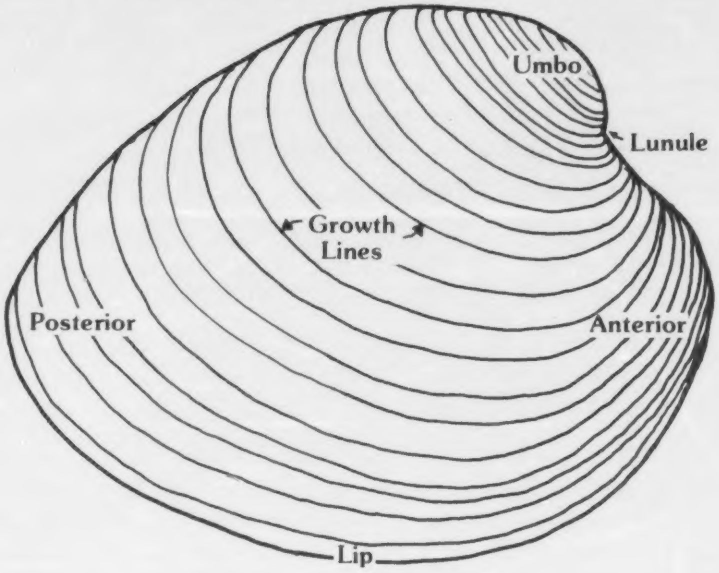
Mailing Address ______
Street or P.O. Box

______
(Village)

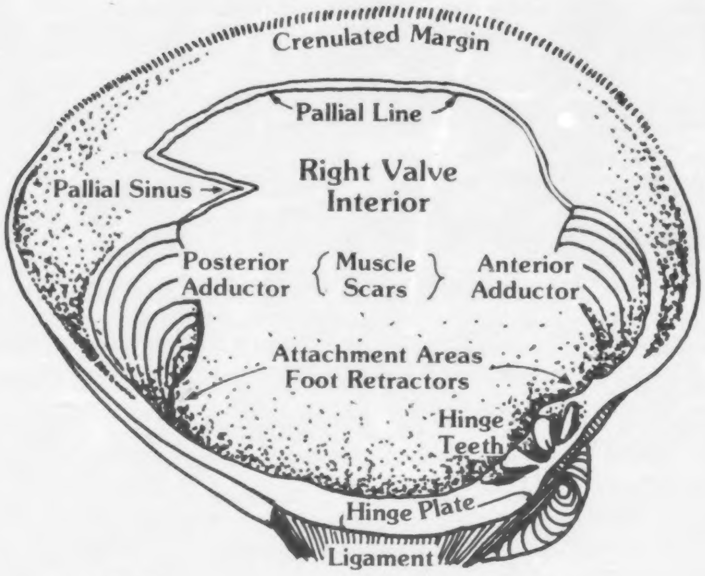
______
(State) (Zip)

Please prepay and allow 4 weeks for delivery.

Outer Surface of Valve

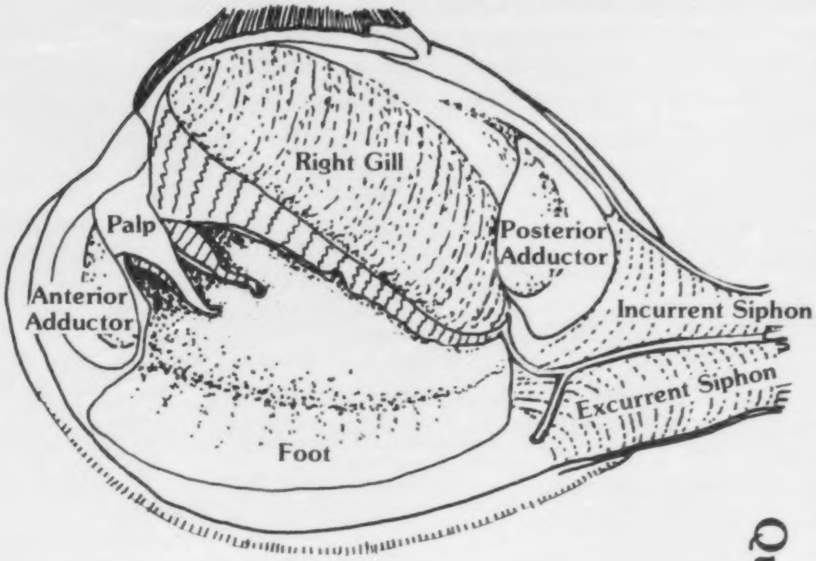

Umbo
Lunule
Growth Lines
Posterior
Anterior
Lip

Inner Surface of Valve

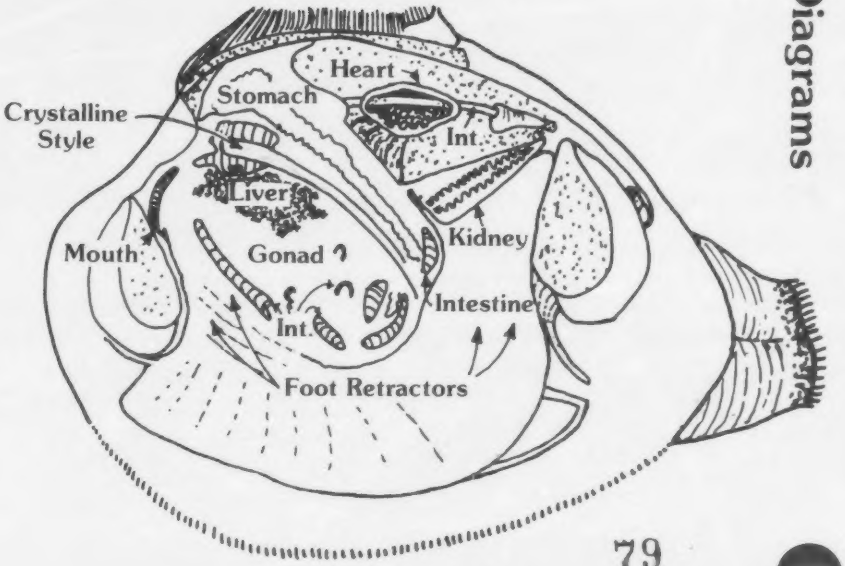

Crenulated Margin
Pallial Line
Right Valve Interior
Pallial Sinus
Posterior Adductor
Muscle Scars
Anterior Adductor
Attachment Areas Foot Retractors
Hinge Teeth
Hinge Plate
Ligament

The Northern Quahog
Mercenaria mercenaria

Outer Surface of Body


Right Gill
Palp
Posterior Adductor
Anterior Adductor
Incurrent Siphon
Excurrent Siphon
Foot

Interior of Body


Heart
Stomach
Crystalline Style
Int.
Liver
Kidney
Mouth
Gonad
Intestine
Int.
Foot Retractors

Student Guide

Laboratory activities:
Students can work in teams of 2-4.

Materials that will be needed:
Living sea star in culture dish, aquaria, sea water slide, cover glass, stereoscope, ruler, timing device, variety of foods, other marine organisms, habitat supplies, hand lens, scalpel

Procedure:
Using a binocular dissecting microscope or a hand lens, locate the following underlined structures and answer the questions. Also, label all diagrams with the underlined words.

A. External Aboral Structures

1. Central **disc** and five **arms**
   What type of symmetry is shown?
   What type of life is such symmetry best adapted?
2. **Madreporite** or sieve plate, a small circular area off center
   What color is it?
3. **Spines** are rough textured projections
   Can you think of a purpose that they might serve?
4. **Anal opening** located in center
   What is its function:
5. **Papula** are finger-like projections between spines.
   What is its function?
6. **Pedicellaria** are pincer-like structures
   Scrape alittle of the aboral surface with a scalpel, mount the scrapings in water on a slide under a cover glass.
   Do you see more than one kind, if so how many?
   What function do they serve and why is this necessary?

B. External Oral Surface

1. **Mouth** located in the center.
2. **Ambulacral Grooves** groove along the center of each arm
3. **Tube Feet**
   How many rows are present in each arm?
   Are they retracted or extended?
   Suction discs at the tip will be difficult to see; can you see them?
4. **Tentacle** — soft at end of each arm
   Touch it and record reaction.
5. **Eyespot** — small and pigmented on the end of each arm.
   What is its function?
   What color is it?

C. Locomotion — the water vascular system

Fill an aquarium with sea water. Sea Stars have a tendency to move up the sides of the aquaria. If they will not move in bright light, move the tank to a dark area.

1. What is the mode of action of the water vascular system?
2. How do the ampulla and tube feet act to effect locomotion?

Measure the rate of locomotion using a ruler and a timing device.

1. Record measurements three times and average them out.

Mark one or two of the arms with a ballpoint pen.

1. Does any one arm take the lead?

Place some mussels on the opposite side of the tank. Record any reactions and time any movements.

Invert the sea star. Observe the righting action.

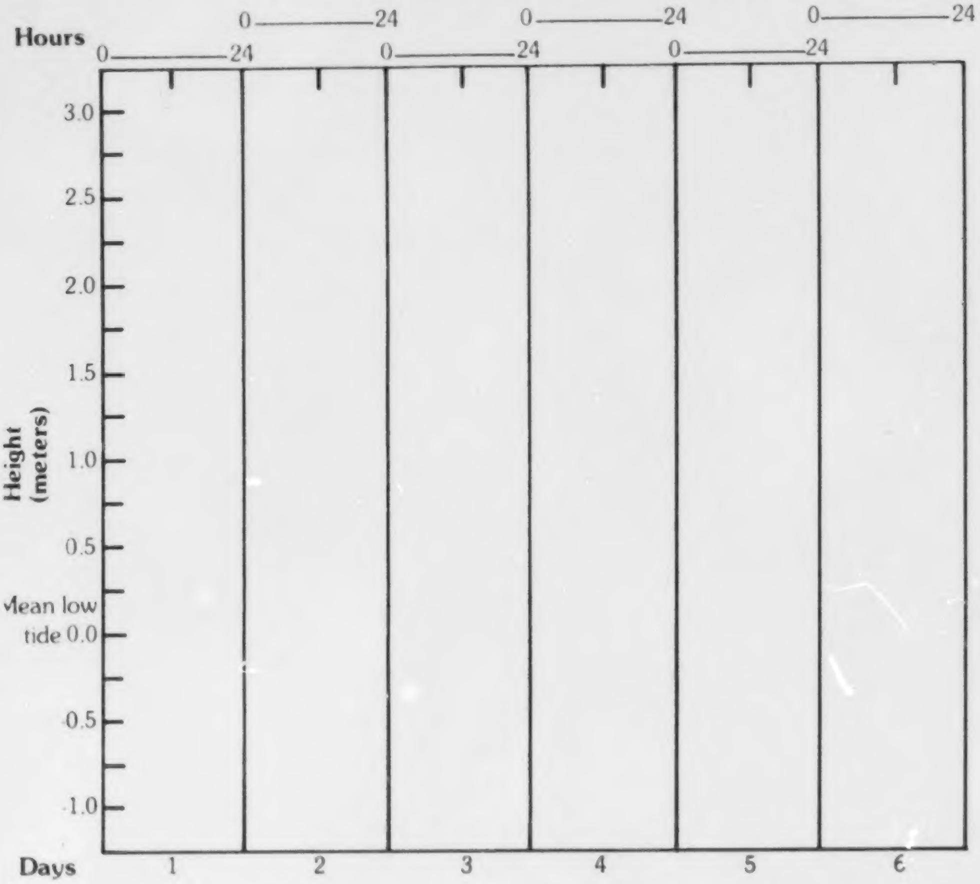
D. Feeding

1. Put some different food in your dish with the sea star, one at a time.
   Record any preferences. (Suggested food: snails, crustaceans, worms, fish.)
   How did they feed?
   Did any everting of the stomach take place?
   How big a piece did they eat?
   Remove any uneaten food at the end of the experiment. Why?

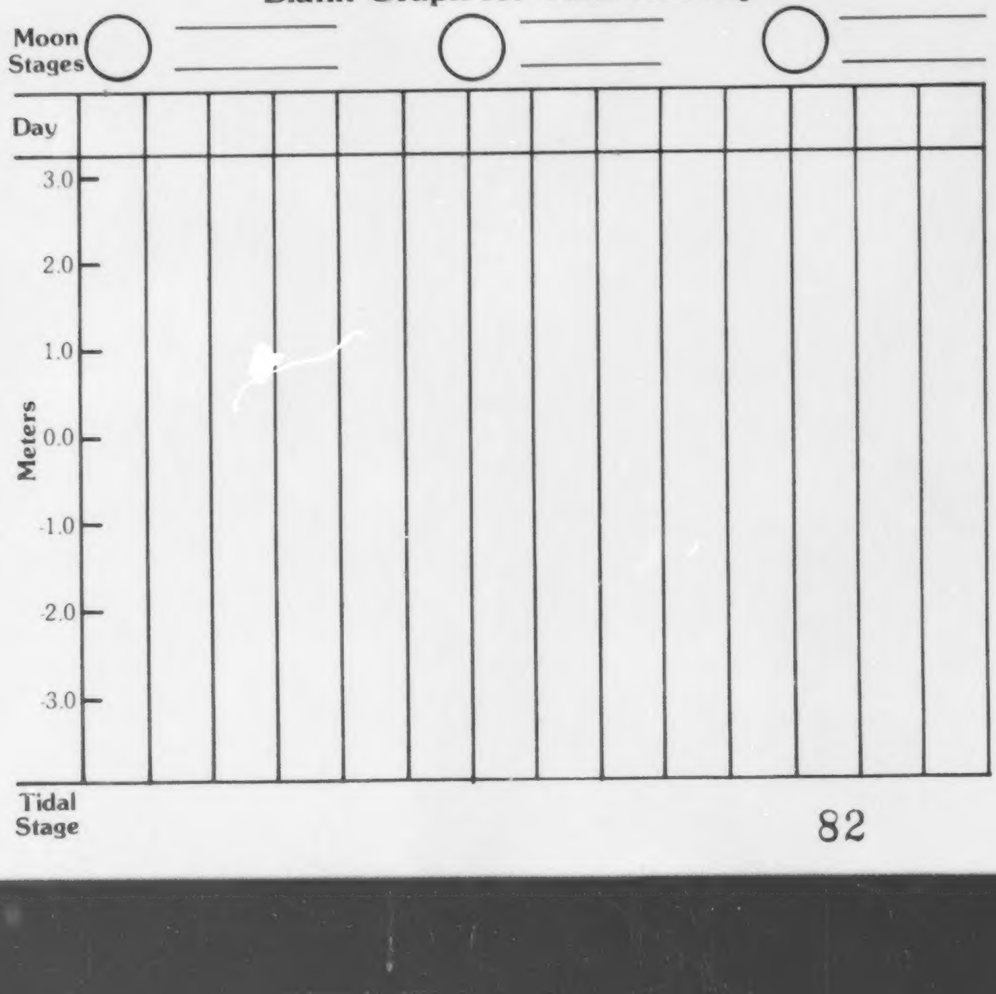
E. Social Behavior

1. Add other sea stars to the dish. Record reactions.
2. Add other organisms (whatever you wish) and record the reactions.
3. Add rocks or any other suitable non-metallic objects that could be used as a habitat. Do they like dark areas? What type of habitat do they seek out?

Blank Graph for Tidal Activity 1



Blank Graph for Tidal Activity 2



PORTLAND, MAINE, 1981

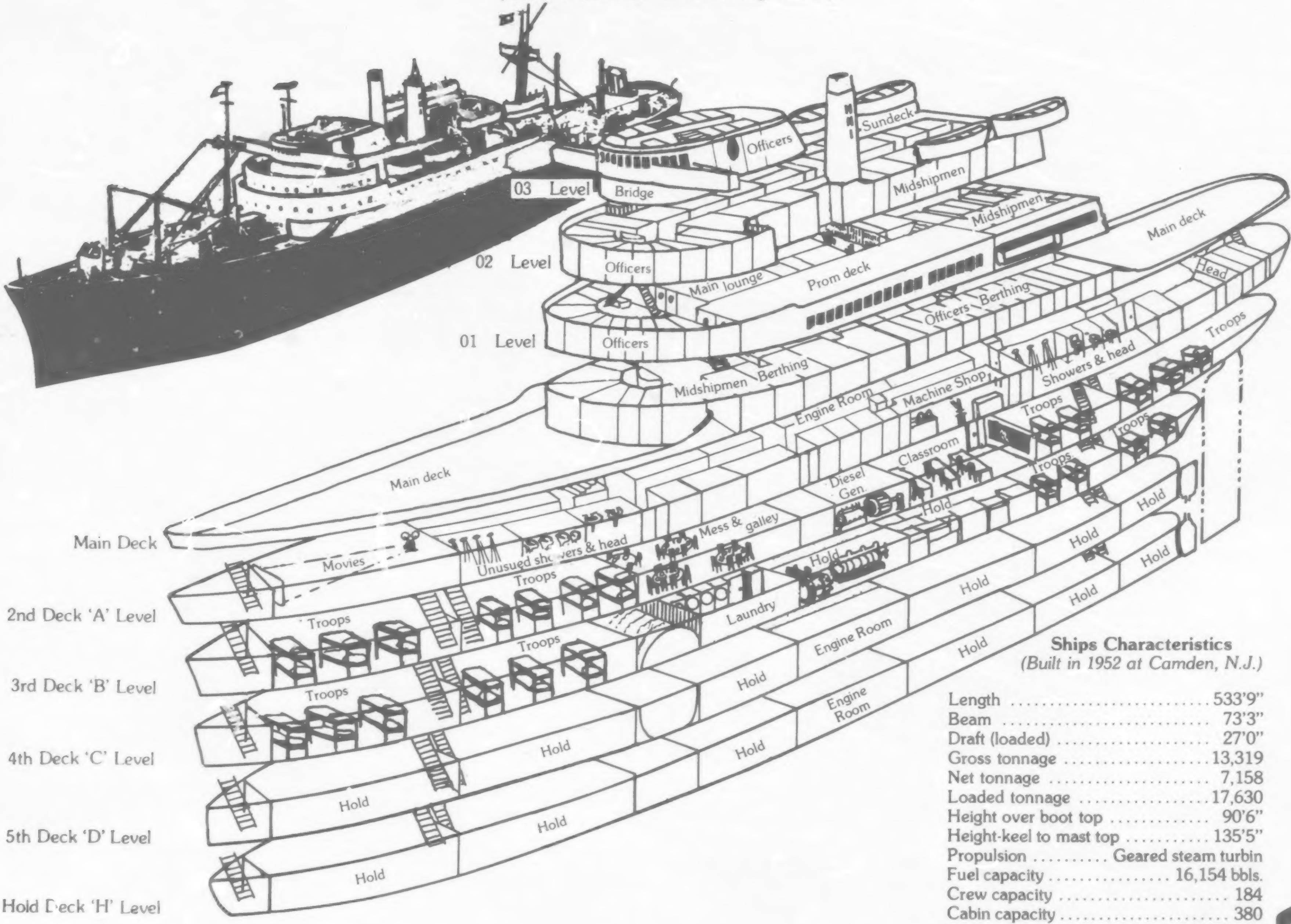
Times and Heights of High and Low Waters

FEBRUARY

Day	Time h.m.	Height ft.	Height m.	Day	Time h.m.	Height ft.	Height m.
1	0201	1.2	0.4	16	0244	0.2	0.1
Su	0817	8.5	2.6	M	0859	9.8	3.0
	1444	0.3	0.1		1527	-0.9	-0.3
	2054	7.6	2.3		2139	8.6	2.6
2	0246	1.0	0.3	17	0338	0.0	0.0
M	0902	8.9	2.7	Tu	0952	9.9	3.0
	1530	-0.1	0.0		1617	-1.0	-0.3
	2139	7.9	2.4		2227	8.8	2.7
3	0331	0.6	0.2	18	0426	-0.1	0.0
Tu	0944	9.3	2.8	W	1039	9.9	3.0
	1612	-0.5	-0.2		1702	-1.0	-0.3
	2219	8.3	2.5		2312	8.9	2.7
4	0414	0.2	0.1	19	0510	-0.2	-0.1
W	1026	9.7	3.0	Th	1122	9.8	3.0
	1651	-0.9	-0.3		1742	-0.9	-0.3
	2300	8.7	2.7		2351	8.9	2.7
5	0455	-0.1	0.0	20	0553	-0.2	-0.1
Th	1108	10.0	3.0	F	1203	9.6	2.9
	1731	-1.2	-0.4		1820	-0.7	-0.2
	2341	9.1	2.8				
6	0539	-0.5	-0.2	21	0027	8.9	2.7
F	1153	10.2	3.1	Sa	0631	-0.1	0.0
	1812	-1.4	-0.4		1242	9.3	2.8
					1854	-0.4	-0.1
7	0023	9.4	2.9	22	0105	8.8	2.7
Sa	0626	-0.7	-0.2	Su	0710	0.0	0.0
	1236	10.2	3.1		1321	8.9	2.7
	1854	-1.5	-0.5		1931	-0.1	0.0
8	0107	9.7	3.0	23	0142	8.7	2.7
Su	0713	-0.9	-0.3	M	0750	0.2	0.1
	1325	10.1	3.1		1359	8.5	2.6
	1941	-1.3	-0.4		2010	0.3	0.1
9	0155	9.8	3.0	24	0221	8.5	2.6
M	0806	-0.9	-0.3	Tu	0835	0.5	0.2
	1417	9.7	3.0		1442	8.1	2.5
	2030	-1.1	-0.3		2051	0.7	0.2
10	0247	9.8	3.0	25	0303	8.3	2.5
Tu	0901	-0.7	-0.2	W	0920	0.7	0.2
	1512	9.3	2.8		1528	7.7	2.3
	2125	-0.6	-0.2		2133	1.1	0.3
11	0343	9.7	3.0	26	0351	8.1	2.5
W	1004	-0.5	-0.2	Th	1013	0.9	0.3
	1615	8.8	2.7		1621	7.3	2.2
	2223	-0.2	-0.1		2225	1.4	0.4
12	0445	9.5	2.9	27	0442	8.0	2.4
Th	1110	-0.4	-0.1	F	1110	1.1	0.3
	1723	8.4	2.6		1720	7.1	2.2
	2329	0.1	0.0		2320	1.6	0.5
13	0550	9.4	2.9	28	0539	7.9	2.4
F	1221	-0.4	-0.1	Sa	1210	1.0	0.3
	1835	8.2	2.5		1823	7.1	2.2
14	0035	0.3	0.1				
Sa	0658	9.5	2.9				
	1329	-0.5	-0.2				
	1943	8.2	2.5				
15	0143	0.3	0.1				
Su	0801	9.6	2.9				
	1431	-0.7	-0.2				
	2044	8.4	2.6				

The New Training Vessel State of Maine

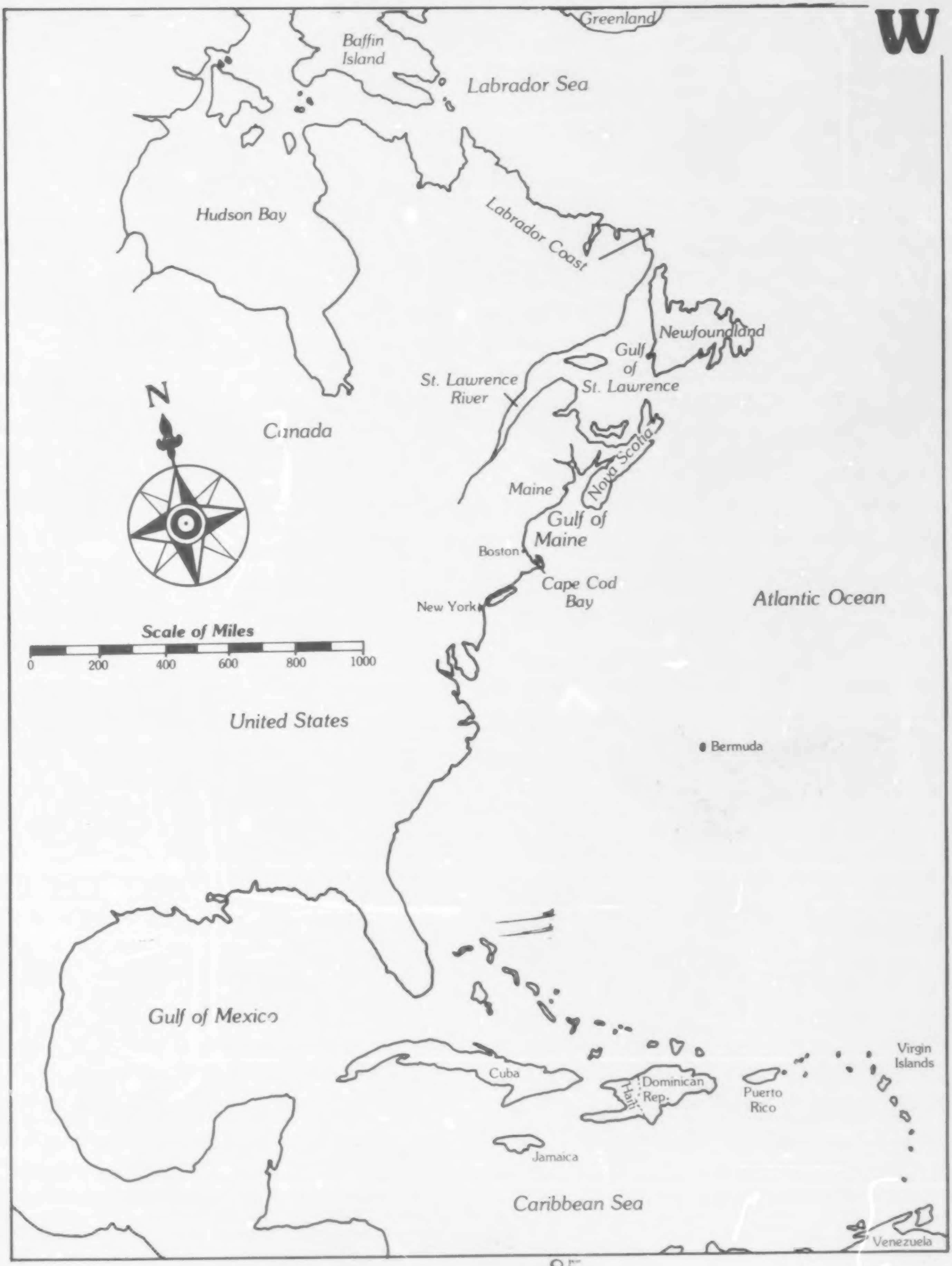
(The Former USNS Upshur)


03 Level
Bridge
Officers
Sundeck
Midshipmen
Midshipmen
02 Level
Officers
Main lounge
Prom deck
Main deck
Head
01 Level
Officers
Officers Berthing
Troops
Showers & head
Midshipmen Berthing
Engine Room
Machine Shop
Troops
Troops
Main deck
Classroom
Troops
Diesel Gen.
Hold
Hold
Main Deck
Movies
Unusued showers & head
Mess & galley
Hold
Hold
Hold
2nd Deck 'A' Level
Troops
Troops
Laundry
Hold
Hold
3rd Deck 'B' Level
Troops
Troops
Engine Room
Hold
Hold
4th Deck 'C' Level
Hold
Engine Room
Hold
5th Deck 'D' Level
Hold
Hold
Hold Deck 'H' Level
Hold

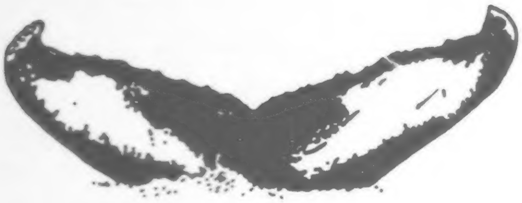
Ships Characteristics
(Built in 1952 at Camden, N.J.)

Length	533'9"
Beam	73'3"
Draft (loaded)	27'0"
Gross tonnage	13,319
Net tonnage	7,158
Loaded tonnage	17,630
Height over boot top	90'6"
Height-keel to mast top	135'5"
Propulsion	Geared steam turbin
Fuel capacity	16,154 bbls.
Crew capacity	184
Cabin capacity	380
Troop capacity	1227-1555

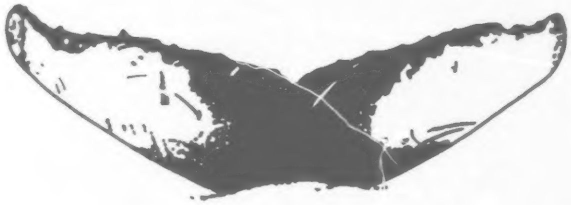
W


Greenland
Baffin Island
Labrador Sea
Hudson Bay
Labrador Coast
Newfoundland
Gulf of St. Lawrence
St. Lawrence River
Canada
N
Nova Scotia
Maine
Gulf of Maine
Boston
Cape Cod Bay
New York
Atlantic Ocean
Scale of Miles
0
200
400
600
800
1000
United States
Bermuda
Gulf of Mexico
Cuba
Haiti
Dominican Rep.
Puerto Rico
Virgin Islands
Jamaica
Caribbean Sea
Venezuela

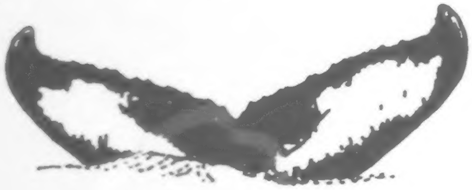
W3



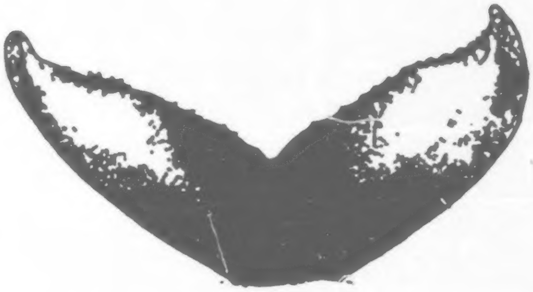
North Coast, Dominican Republic 8 March, 1978



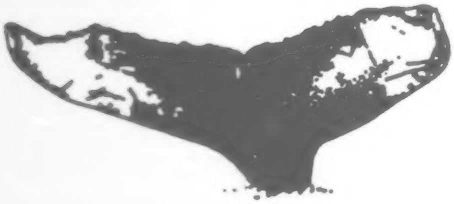
East Coast, Newfoundland 21 August, 1979



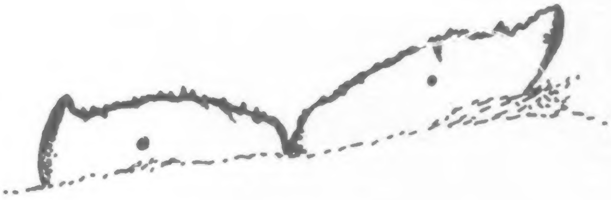
Cape Cod Bay 10 September, 1976



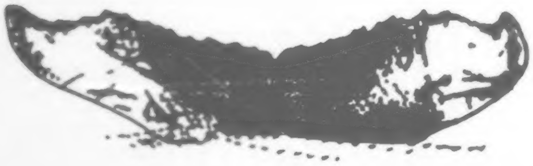
East Coast, Labrador 24 August, 1979



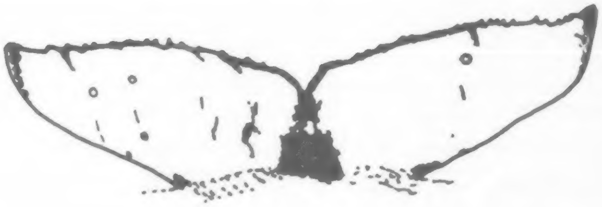
Cape Cod Bay 11 June, 1978



East Coast, Newfoundland 16 June, 1979

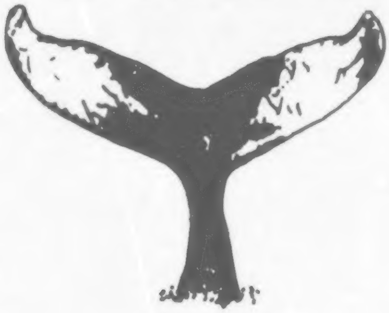


Cape Cod Bay 23 May, 1979

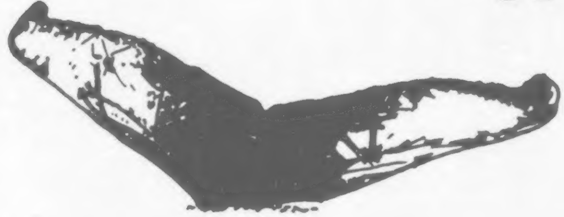


East Coast, Newfoundland 11 September, 1979

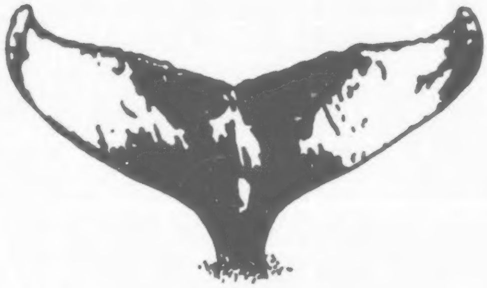
W1



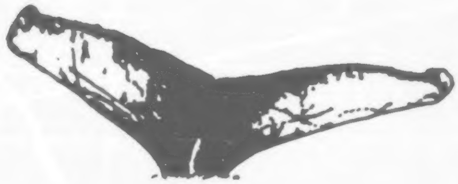
East Coast, Newfoundland 15 July, 1978



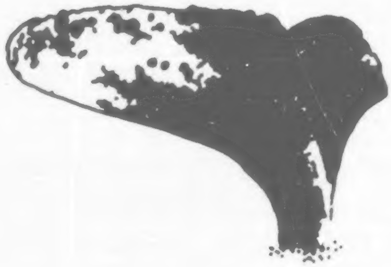
East Coast, Newfoundland 8 August, 1979



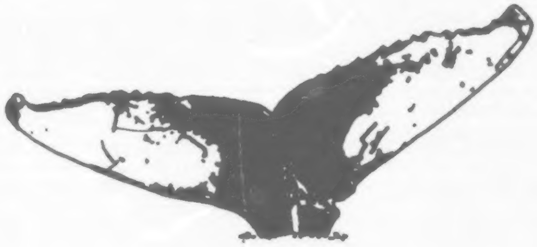
Puerto Rico 3 March, 1979



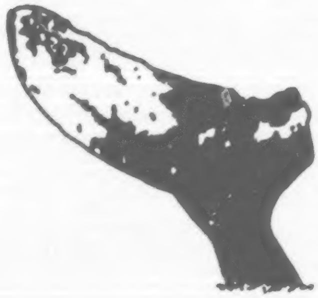
Puerto Rico 8 February, 1979



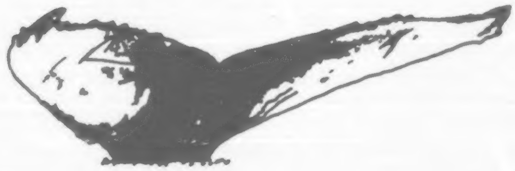
Cape Cod Bay 23 May, 1979



South Coast, Greenland 31 July, 1981

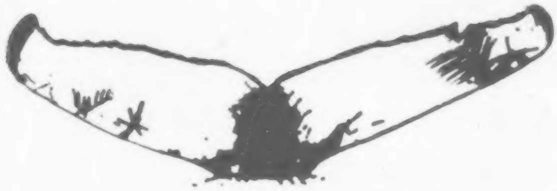


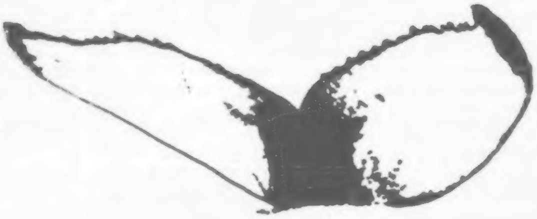
Cape Cod Bay 26 August, 1979

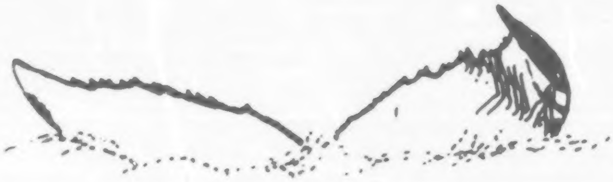


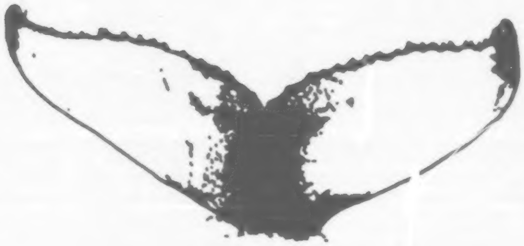
North Coast, Dominican Republic
10 January, 1981

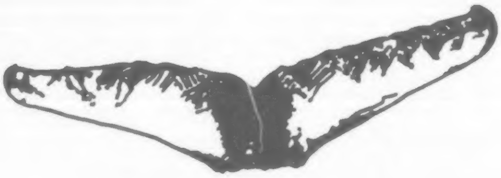
W2

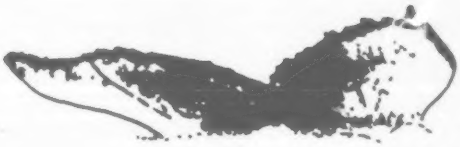

East Coast, Newfoundland 2 July, 1979

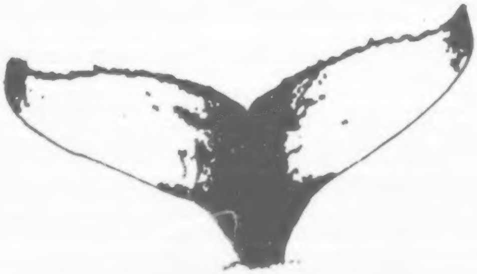

Cape Cod Bay 9 July, 1979


East Coast, Newfoundland 20 July, 1978

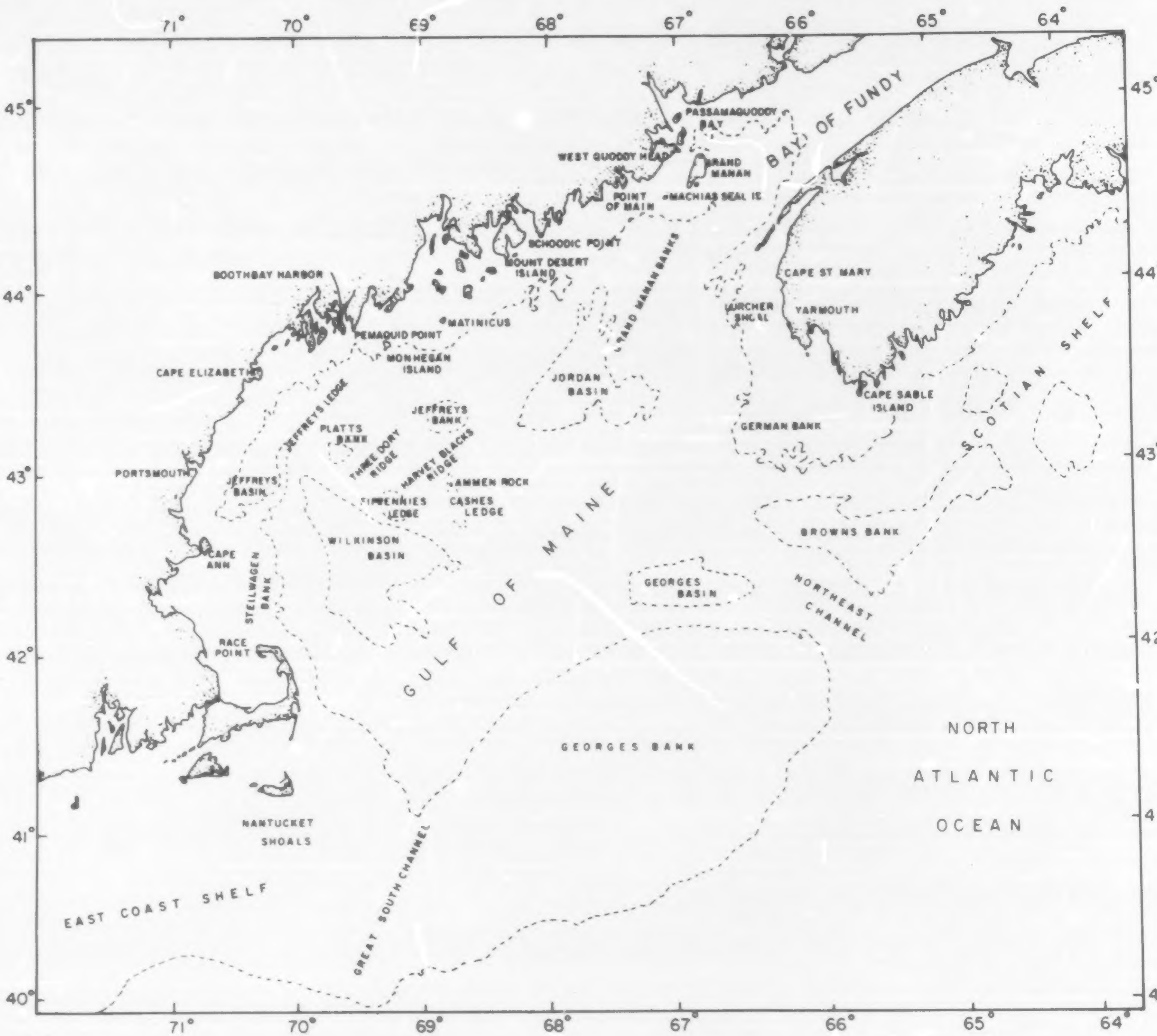

North Coast, Dominican Republic
1 January, 1978


East Coast, Newfoundland 31 July, 1979


Dominican Republic 10 April, 1979


Cape Cod Bay 1 May, 1976

Maine Coast 27 July, 1976


71°
70°
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67°
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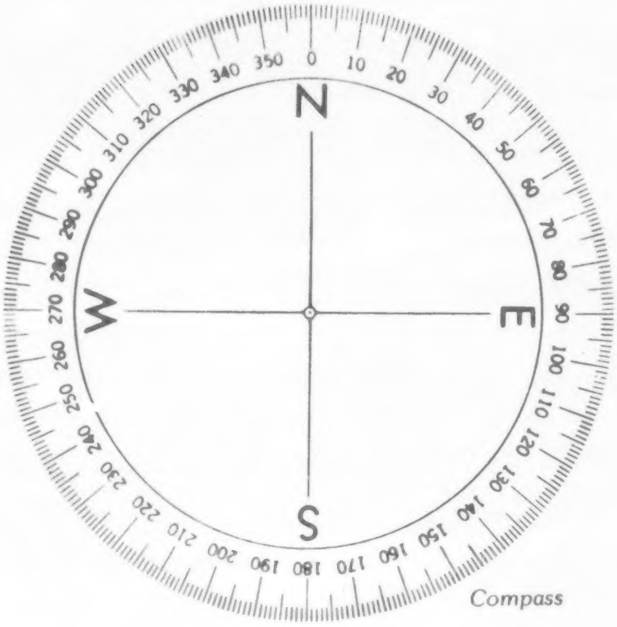
64°
45°
44°
43°
42°
41°
40°
PASSAMAQUODDY BAY
BAY OF FUNDY
WEST QUODDY HEAD
GRAND MANAN
POINT OF MAIN
MACHIAS SEAL IS
SCHOODIC POINT
MOUNT DESERT ISLAND
GRAND MANAN BANKS
BOOTHBAY HARBOR
MATINICUS
PEMAQUID POINT
MONHEGAN ISLAND
CAPE ST MARY
LURCHER SHOAL
YARMOUTH
CAPE ELIZABETH
JORDAN BASIN
JEFFREYS LEDGE
JEFFREYS BANK
PLATTS BANK
THREE DORY RIDGE
HARVEY BLACKS RIDGE
CAPE SABLE ISLAND
GERMAN BANK
SCOTIAN SHELF
PORTSMOUTH
JEFFREYS BASIN
AMMEN ROCK
FIPPENNIES LEDGE
CASHES LEDGE
WILKINSON BASIN
GULF OF MAINE
BROWNS BANK
CAPE ANN
STELLWAGEN BANK
GEORGES BASIN
NORTHEAST CHANNEL
RACE POINT
GEORGES BANK
NORTH ATLANTIC OCEAN
NANTUCKET SHOALS
EAST COAST SHELF
GREAT SOUTH CHANNEL

Yacht Race Chart

Y

Y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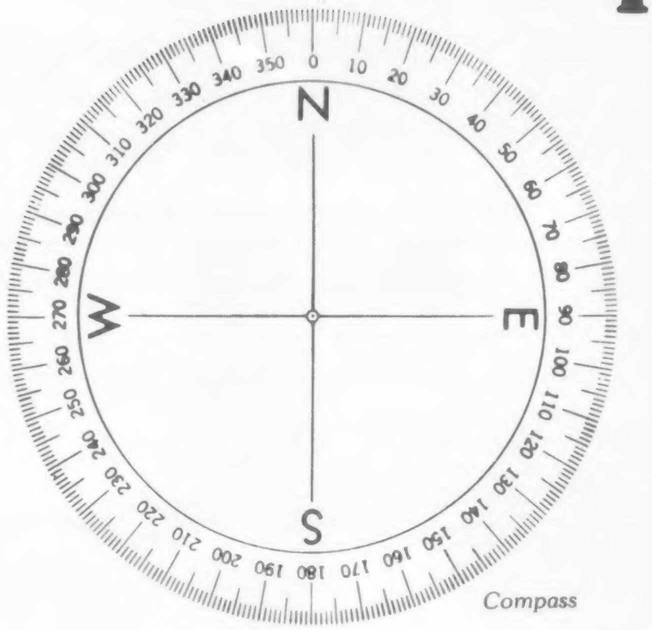
340
350

Compass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220
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270
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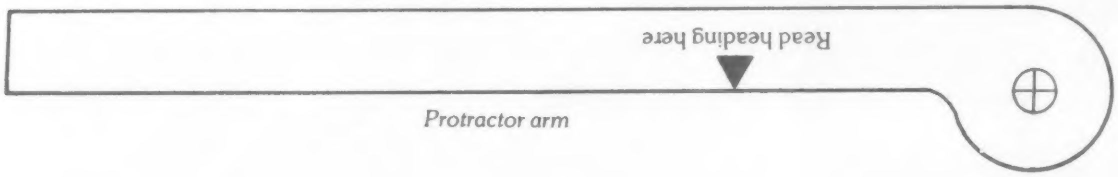
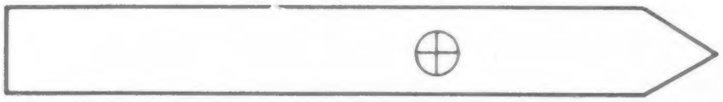
320
330
340
350

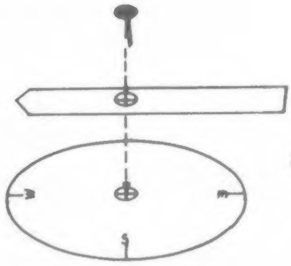
Compass


Read heading here

Protractor arm

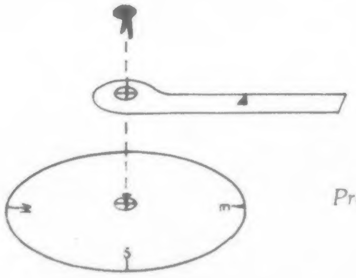


Spinner arrow



Spinner assembly

Mount all pieces on cardboard first. Cut out pieces. Using a hole punch, punch out holes marked ⊕. Insert brass fastener through centers of pieces to be joined so pieces are secure but still move freely.



Protractor assembly